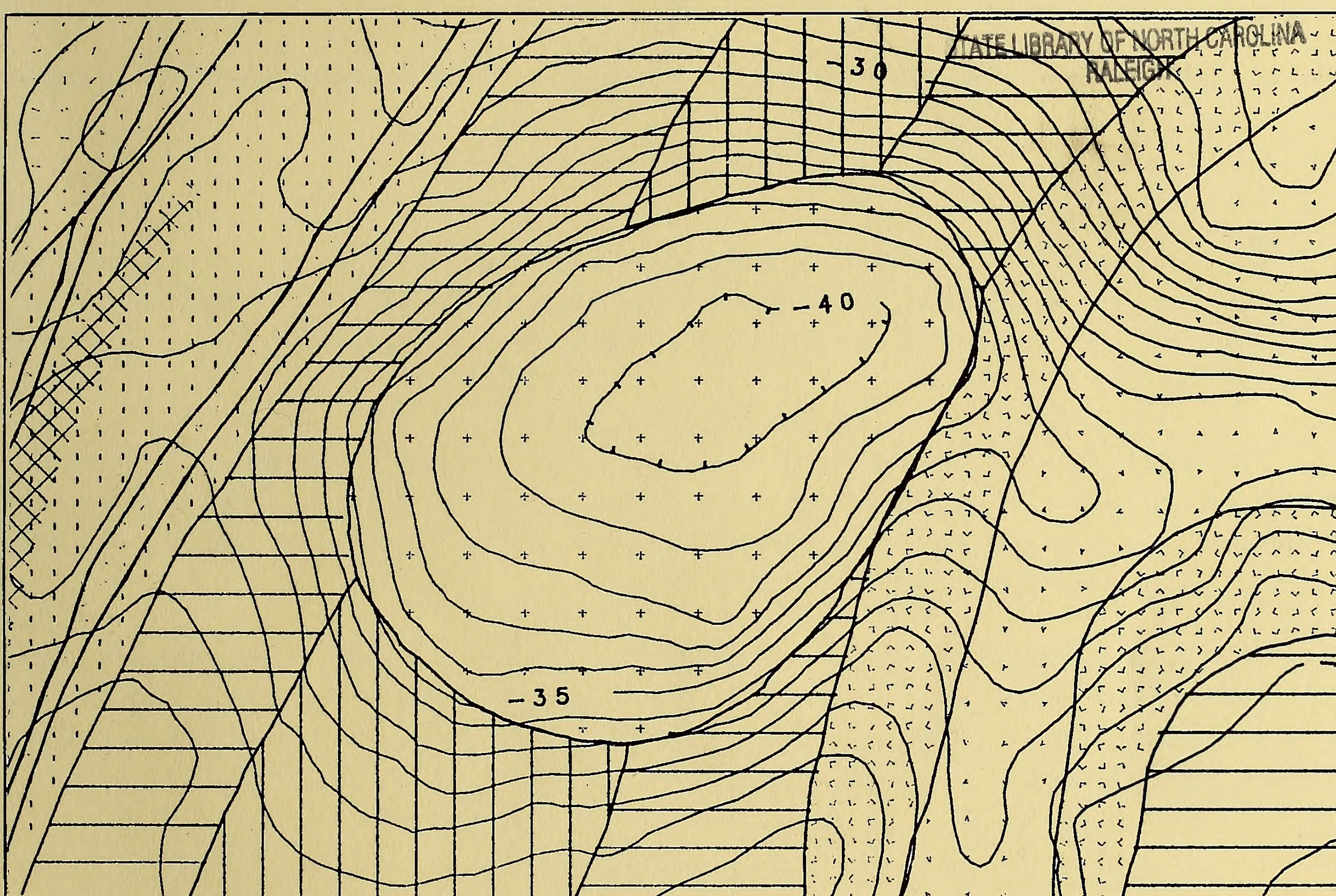
THE SIMS PLUTON, NASH AND WILSON COUNTIES, NORTH CAROLINA

By

J. Alexander Speer

BULLETIN 97



NORTH CAROLINA GEOLOGICAL SURVEY

DIVISION OF LAND RESOURCES

DEPARTMENT OF ENVIRONMENT, HEALTH AND NATURAL RESOURCES

Geological Survey Section

The Geological Survey Section examines, surveys, and maps the geology, mineral resources, and topography of the state to encourage the wise conservation and use of these resources by industry, commerce, agriculture, and government agencies for the general welfare of the citizens of North Carolina.

The Section conducts basic and applied research projects in environmental geology, mineral resource exploration, and systematic geologic mapping. Services include identifying rock and mineral samples submitted by citizens and providing consulting services and specially prepared reports to agnecies that need geological information.

The Geological Survey Section publishes Bulletins, Economic Papers, Information Circulars, Educational Series, Geologic Maps and Special Publications. For a list of publications or more information about the section please contact the Geological Survey Section at P.O. Box 27687, Raleigh, North Carolina 27611-7687, or call (919) 733-2423.

Jeffrey C. Reid
Chief Geologist

THE SIMS PLUTON, NASH AND WILSON COUNTIES, NORTH CAROLINA

By

J. Alexander Speer
Mineralogical Society of America
1718 M Street, N.W.
Washington, D.C. 20036

NORTH CAROLINA GEOLOGICAL SURVEY

BULLETIN 97

1997

CHARLES H. GARDNER, DIRECTOR AND STATE GEOLOGIST

STATE OF NORTH CAROLINA
JAMES B. HUNT, JR., GOVERNOR

DEPARTMENT OF ENVIRONMENT,
HEALTH AND NATURAL RESOURCES
JOHNATHAN B. HOWES, SECRETARY

CONTENTS

ILLUSTRATIONS

TABLES

THE SIMS PLUTON, NASH AND WILSON COUNTIES, NORTH CAROLINA

by

J. Alexander Speer, Mineralogical Society of America

ABSTRACT

The Sims pluton of Alleghanian age (288 ± 13 Ma) is an egg-shaped, composite body about 50 km² (20 mi²) in area within the Eastern slate belt of North Carolina. It is a centered pluton comprising two major lithologies, the Conner (rim) and Sims (core) granitoids, and a number of minor granitoids that occur as dikes or other small intrusive bodies within the pluton. A 1.5 x 0.5 km greisen-bearing zone is developed by replacement of the Conner granitoid within the southeastern margin of the pluton. Both major facies are coarse-grained, biotite monzogranites. The Conner granitoid contains alkali feldspar megacrysts up to 5 cm whereas the Sims is equigranular. The Conner granitoid contains monazite, relatively abundant sulfide minerals, and only minor magnetite whereas the Sims contains allanite, a low abundance of sulfide minerals, and greater modal amounts of magnetite. There is a gradational contact between the two lithologies. Neither granitoid shows visible magmatic flow structures. Contact metamorphic rocks include garnet-bearing tactites and biotite + muscovite ± andalusite hornfelses and are sparsely developed.

The two granitoid facies are identical in terms of modal and major and most trace element compositions. Significant compositional differences are the higher S, U, Nb, Ta, and hydrophile element Li, Be, Rb, Sr, Cs contents of the Conner, and the higher transition metals Zn, Pb, Cu contents of the Sims. Biotites of the Conner granitoid are more Fe-rich, F-rich, and aluminous than those in the Sims, but there is a continuous compositional gradation between them related by the Tschermak [$^{iv}Al^{vi}Al(Fe,Mg)_{-1}Si_{-1}$], [$OHF_{-1}$], [$MgFe_{-1}$] exchanges, and solid solution with the dioctahedral micas.

Textural and compositional features of the granitoids indicate the composite pluton formed from a single magma batch, portions of which crystallized under differing conditions to form the different lithologies. Varietal mineralogy of the two major facies are related by the reaction: Conner Fe-rich biotite + O_2 <=> Sims Mg-rich biotite + K feldspar + magnetite. The magma was emplaced vapor undersaturated. Vapor saturation occurred once solidification reached the Conner-Sims boundary. With vapor saturation, nucleation rates for the major minerals became nearly equal and the rock texture changed from inequigranular to equigranular. With vapor saturation, some components fractionated into the separate volatile phase. Migration of the volatile phase from the central Sims granitoid caused relatively reduced conditions by dissociation of H_2O and loss of H_2. The outwardly migrating fluids reacted with the already crystallized surrounding Conner granitoid to form OH-bearing minerals and release of O_2. Segregation and migration of a fluid to the western margins of the pluton formed both the greisen zone by replacement of the Conner granitoid and the abundant aplite dikes. Subsequent, and lower temperature fluid migration would form the widespread mineralized fractures. During these fluid migrations, there was redistribution of the trace elements, especially the hydrophile elements. The occurrence of the mineralizations in linear zones and fractures indicates structural control. The pluton was emplaced at depths corresponding to pressures less than the aluminum silicate triple point (<4 kbar, or <15 km depth).

The Sims pluton causes anomalies in the regional gravity, magnetic, radiometric, and geochemical fields. The small negative gravity anomaly and density difference of 0.13 g cm^{-3} with the surrounding rocks makes it unlikely that the pluton is significantly larger at depth. Magnetic and radiometric anoma-

lies reveal variations within the pluton. The positive magnetic anomaly of the pluton coincides with that portion of the Conner granitoid with the thinnest coastal plain cover and containing magnetite. The greatest radiometric maximum coincides with abundant aplite dikes in the northwestern margin of the pluton. The soils developed on the Sims pluton have a median soil-gas radon concentration of 2,289 pC/l compared to a median concentration of 1,192 pC/l for the surrounding slate belt and 323 pC/l for soils developed on the overlying coastal plain. The greatest soil gas radon concentrations (up to 6341 pC/l) are in the vicinity of abundant aplite dikes. Median groundwater radon concentration in the granitoids is 20,252 pC/l, whereas the groundwater of the slate belt rocks is 2,041 pC/l.

The equigranular, automorphic Sims granitoid is presently being quarried for crushed stone. The greisen, along with the intermixed granite, is a potential source of mica, feldspar, and quartz. Elevated Mo concentrations in the soils is associated with the greisen that contains disseminated and vein Mo mineralization. The adjacent Eastern slate belt rocks have elevated Cu concentrations.

INTRODUCTION

The Sims pluton is a granitic body within the Eastern slate belt largely covered by a thin layer of Atlantic Coastal Plain sediments. It has also been referred to as the Conner stock (Cook, unpub. data, 1972; Cook, 1972). The Sims pluton lies on the border of Wilson and Nash Counties, North Carolina in the eastern part of the Raleigh 30 x 60-minute quadrangle. The center of the pluton nearly coincides with the location where the Bailey, Middlesex, Lucama, and Stancils Chapel U.S. Geologic Survey 1:24,000-scale topographic quadrangle maps meet (fig. 1).

The objective of this investigation was to characterize the distribution and nature of the granitoids and any contact aureole in order to understand and evaluate the geologic evolution, economic potential, and geophysical and geochemical expression of the Sims pluton. Much of the previous work on the pluton has been reconnaissance with most, if not all, samples examined obtained from the Neverson Quarry. The results of these previous studies produced a picture of a granitoid unlike the other igneous rocks of similar age in the southeastern U.S. Such an unusual Alleghanian granitoid warranted further study. Like most granitoids in the southern Appalachians, the Sims pluton has been a source of both dimension and crushed stone. However, unlike most, its potential for economic deposits of copper, zinc, molybdenum, tin, tungsten, mica, and feldspar have all been extensively explored. Additionally, the paleotopographic expression of the pluton appears to have been responsible for concentration of heavy minerals in economic amounts in the overlying Coastal Plain sediments. The composition and physical properties of the Sims pluton contrast with those of the enclosing rocks, and with other granitoids. These contrasts give rise to physical and chemical anomalies immediately evident on regional maps of gravity, magnetics, radioactivity, and geochemistry.

Most of the geologic mapping for this report was done between March and December, 1990. Laboratory studies to obtain mineral and rock compositions continued until May, 1991. The work was conducted as part of a cooperative effort (COGEOMAP) among the North Carolina Geological Survey, U. S. Geological Survey, and N. C. State University.

In addition to the work done for that project, this report incorporates the results of other unpublished investigations. Radon concentrations measured in the soil gas and groundwater of the area are from Speer (unpub. data, 1992, 1994). The Lindgren Exploration Company of Wayzata, Minnesota did detailed field mapping, trace element geochemistry, and drilling of the

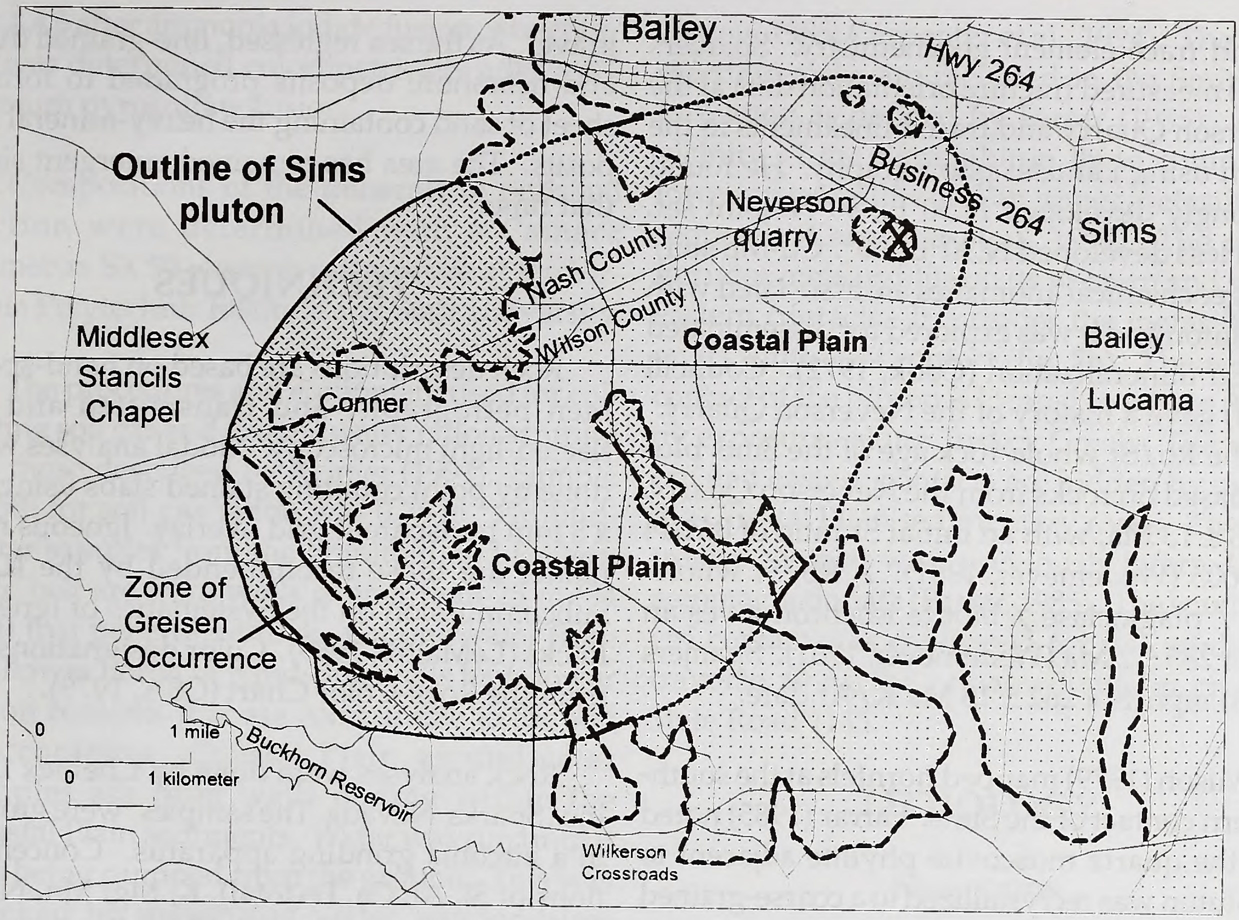


Figure 1. Location map of the Sims pluton, N.C. and overlying Atlantic coastal plain with regard to cultural features, county lines, and U.S.G.S. 7.5' topographic maps.

granitoid and adjacent wall rocks between 1968 and 1979 (Kiff, unpub. data, 1968; Kiff and Schell, unpub. data, 1969; Claus and Smith, unpub. data, 1970, 1971; Cook, unpub. data, 1972; Bartlett, unpub. data, 1975; Bartlett and Johnson, unpub. data, 1979). The Sims pluton and adjacent wall rocks were thought to be among the more attractive possibilities for base metal deposits. Newmont Exploration also examined the area (Hausen, unpub. data, 1979).

Unpublished data was also obtained from the N.C. Department of Transportation. It has tested the aggregate produced from the Neverson Quarry yearly since 1982 to assure compliance with standards for road aggregate.

PREVIOUSLY PUBLISHED WORK

Published maps which delineate the pluton are preliminary geologic maps of Nash and Wilson counties (Wilson and Spence, 1979; Wilson, 1979), the NC Geologic Map (N. C. Geological Survey, 1985), and the regional mapping by Farrar (1985). Petrographic descriptions of the granitoids appear in Councill (1954), Wedemeyer (1981) and Farrar (1985).

Cook (1972), Barwick et al. (1978), Wedemeyer (1981), and Speer et al. (1980) have reported on the mineralogy of the Sims pluton and associated mineralization. Sando (1979) and Wedemeyer (1981) determined some ma-

jor and trace element geochemistry. Spanjers (1983) measured fracture orientation data at the Neverson Quarry and traced lineaments in the region using Landsat photography. He found a strongly developed N.50°E., 30°N. joint set, and a less developed N.30°E., 90°. Cu-Mo soil/ rock geochemical anomalies are associated with the pluton and it was explored for disseminated Mo-Cu mineralization (Cook, 1972). Councill (1954) gave a history of the Neverson Quarry.

The Rb/Sr whole-rock age of the Sims pluton, based on rocks from the Neverson Quarry, is 288 ± 13 Ma, with an initial Sr ratio of 0.7044 ± 0.0005 (Wedemeyer, 1981). A Rb/Sr whole-rock / plagioclase / biotite isochron gives an age of 285 ± 2 Ma (Wedemeyer, 1981). Spanjers (1983) reports a 262 ± 13 Ma K/Ar date.

Wilson (1979) mapped hornfels at the southeastern contact of the Sims. Farrar (1985) noted that the quartz muscovite phyllite adjacent to the pluton was recrystallized to a coarse-grained quartz muscovite hornfels. He also reported a pelitic xenolith from the Neverson Quarry with the assemblage biotite + andalusite + fibrolite + quartz + muscovite.

Carpenter and Carpenter (1991) described the heavy-mineral deposits which occur in the Coastal Plain sediments in the area. The high-grade portion of the Bailey heavy-mineral deposit, termed the Bailey South deposit, overlies the Sims pluton (Mallard, 1992, *in* Hoffman and Carpenter, 1992). Hoffman and Carpenter (1992) described more fully the stratigraphy and depositional environment of the sedimentary rocks containing these deposits. They presented a structural contour map and several cross-sections of the nonconformity of the Sims pluton and adjacent country rocks with the overlying Coastal Plain sedimentary rocks. The Sims pluton was a paleographic high during the Pliocene transgression. It remained emerged as an island, developing an apron of coarse sand and gravel. As the sea regressed, fine-grained dune and nearshore deposits prograded to form a sheet of sand containing the heavy-mineral deposits. The area has remained emergent since that time.

TECHNIQUES

Rock descriptions are based on hand-specimen petrography and transmitted and reflected-light microscopy. Modal analyses were done by point counting stained slabs using a 5 x 5 mm transparent grid overlay. Igneous rock names are those recommended by the IUGS Subcommission on the Systematics of Igneous Rocks (LeMaitre, 1989). Color designations are from the Rock-Color Chart (GSA, 1979).

Rock analyses were done by Chemex Labs Inc., Sparks, Nevada. The samples were ground in a zirconia grinding apparatus. Concentrations of Si, Al, Ca, Fe(total), K, Mg, Mn, Na, P, Ti were measured by ICP-AES following a nitric-aqua-regia digestion of a fused meta-borate fusion. FeO was measured by titration after acid digestion. C and S were determined on a Leco IR detector/induction furnace. Crystalline and surface water were determined with a Leco RMC100. F was determined by specific ion electrode after a carbonate-nitrate fusion. Nb and Y were determined by x-ray fluorescence. Cl, Cs, Hf, Sc, Ta, Th, U, and the REE were done by neutron activation analysis (NAA). Be, Ga, Ge, Li, and Rb were done by Atomic Absorption Spectrophotometry (AAS) after a perchloric-nitric-hydrofluoric acid digestion. Ga had an organic extraction and the AAS was corrected for background. Cd, Co, Ni, Cu, Zn, Mo, Pb were analyzed by AAS following an aqua regia digestion. Cd, Co, Ni, and Pb were corrected for background. Cr, Sr, V, Ge, Ba were analyzed by AAS following a perchloric-nitric-hydrofluoric acid digestion. B was analyzed by prompt-gamma neutron activation. Sn was determined

by AAS after ammonia iodide fusion extraction. W was determined colorimetrically after a potassium pyrosulfate fusion.

Compositions of the minerals in polished section were determined with a Cameca Camebax SX 50 electron microprobe at the Virginia Polytechnic Institute and State University.

The procedures and equipment used for collecting soil gas and groundwater radon samples are those described by Reimer (1991). Sample depth for soil gas radon was 0.75 m. Groundwater samples from the granitoid and Eastern slate belt are from wells deeper than 25 m (84 feet) that penetrated rock. Groundwater from shallower bored or hand-dug wells have lower radon contents that are comparable to the soil gas contents. Coastal Plain groundwater samples are from wells ending within the Coastal Plain sediments. Water was run until it was being pumped from the ground. This was checked by measuring water temperatures which are generally <18°C in the ground. Radon was measured on 20 cc of gas sample using Lucas cells and a Bondar-Clegg & Co., Ltd. model RE-279 alpha-scintometer. Counting was begun five minutes after injection of gas into the Lucas cell. Two-minute counts were taken and recorded until a reading that is lower than the previous one was obtained. At that point, a succession of five (5) 2-minute counts were taken and used for the radon concentration determination.

GEOLOGIC SETTING

The Sims is an egg-shaped pluton with an area of approximately 50 km^2 (20 square miles) (fig. 2). The pluton occurs in the Spring Hope tectonostratigraphic terrane of Horton et al. (1989). It is emplaced in greenschist-grade metasedimentary rocks of the Eastern slate belt along the axial trace of the Smithfield synform (Farrar, 1985; Carpenter et al., 1994). The metamorphic rocks are included in the Smithfield formation as defined by Farrar (1985). In the vicinity of the Sims pluton these comprise a lower metaargillite and an upper metasiltstone sequence (Carpenter et al., 1994). The pluton intrudes metaargillite on its western and southeastern contacts. It intrudes the metasiltstone on its southwest contact (fig. 2b). The western contact of the pluton is located to within 0.2 km by exposures along Turkey Creek. The northern and eastern contacts are hidden by overlying Coastal Plain sedimentary rocks. These intrusive contacts were previously inferred from aeromagnetic data (Farrar, 1985). The southeastern contact was confirmed for this study in a traverse along the unnamed stream crossing State Road 1145.

LITHOLOGY

Sims pluton

The Sims pluton is a composite body with two major and several minor lithologies. Both major lithologies (Conner and Sims) are coarse-grained biotite granitoids, but differ in the appearance of the alkali feldspars, color, degree of alteration, accessory mineralogy, and mineral compositions.

Much of the previous work on the pluton was confined to either the Neverson Quarry in the northeast portion or the mineralized area in the southeast portion of the pluton. Starting with Councill (1954), workers refered to the rock in the Neverson Quarry near the town of Sims as the granite at Sims or the Sims granite. The igneous body was eventually termed the Sims as well by Wedemeyer (1981). The Lindgren Exploration Company worked in the southeast portion of the body near the community of Conner. Kiff and Schell (unpub. data, 1969) first termed the rock the Conner granite and the ig-

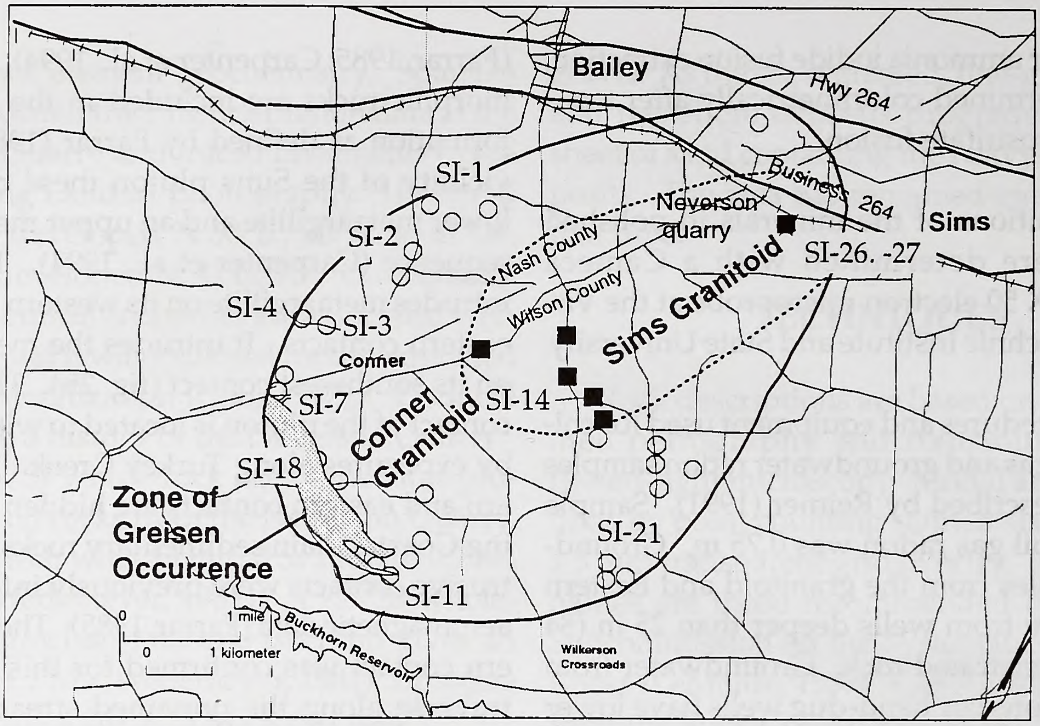


Figure 2a. Geologic sketch map of the Sims pluton, NC showing the distribution and location of outcrops and numbered samples collected for this study for the Conner granitoid (open circles), Sims granitoid (filled squares), and greisen zone.

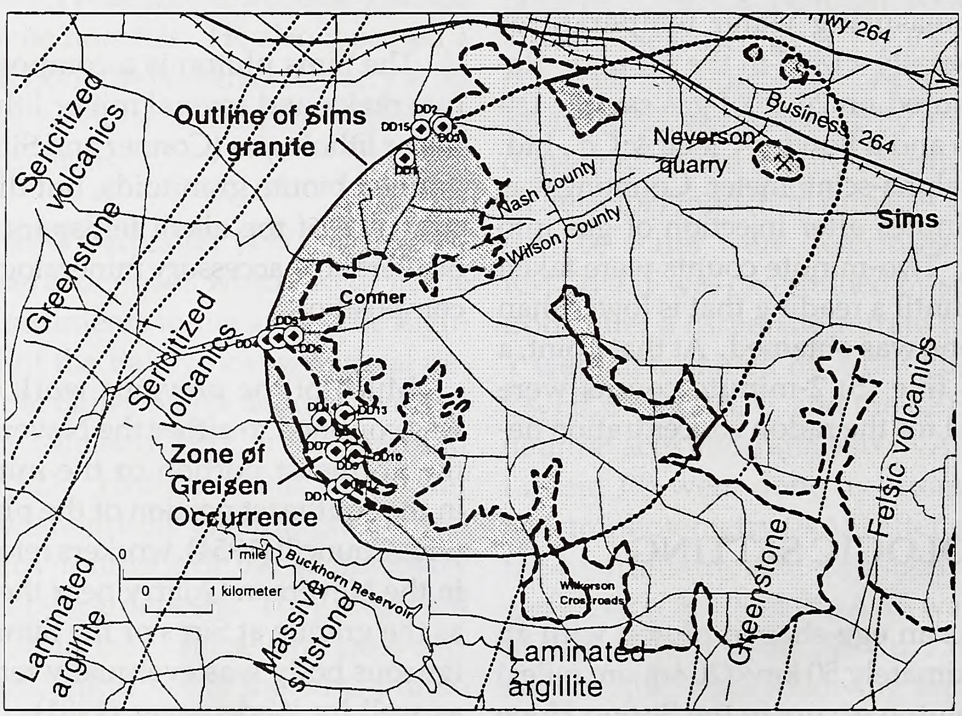


Figure 2b. Contacts of the Eastern slate belt lithologies in the vicinity of the Sims pluton from Carpenter et al., unpublished, 1995 (Middlesex), Carpenter et al., 1995 (Stancils Chapel), and Hoffman et al., unpublished (Lucama). Drillholes are the bedrock diamond core drilling program of the Lindgren Exploration Company (Claus and Smith, unpub. data, 1971).

neous body the Conner stock. The rocks in the two areas are petrographically distinct facies of the pluton. Because of this fortuitous happenstance, the two names are retained for the two distinct lithologic facies in the pluton: the Conner and Sims granitoids.

The proper or suitable name for the pluton is problematical. Taking their cue from Council's (1954) label of the body as the granite of the Sims area, all but one of the published papers on the pluton refer to it as the Sims. The Lindgren unpublished reports refer to it as the Conner stock as early as 1969, but this name only appears in print with the abstract by Cook (1972). Because the pluton is most commonly refered to in print as the Sims, that usage is retained here. Sims is the name as one of the constituent facies as well. This is a unavoidable consequence of retaining continuity with past usages. It is not the only case. For example, the Liberty Hill pluton of South Carolina contains two major facies: the Kershaw and Liberty Hill granitoids (Wagener, 1977).

Conner granitoid

The western and southern sides of the pluton (fig. 2a) comprise coarse-grained, biotite granitoid. Modal analysis shows the rocks are granites with a color index (CI) < 5 (table 1, fig. 3). The rocks lie in that area of the granite field designated monzogranite in the IUGS system (LeMaitre, 1989). The texture is automorphic granular with no discernible mineral alignment. The rock contains abundant alkali feldspars which are subhedral to euhedral, tabular crystals up to 5 cm (2 inches) across. Because the other minerals in the rock are less than 1 cm across, the alkali feldspar megacrysts give the rock a hiatal or inequigranular texture (fig. 4a). The alkali feldspar is conspicuous mineral in outcrop because of its prominent relief on weathered surfaces. The alkali feldspar is very pale orange in rocks on the northwest corner of the pluton and grades through grayish orange pink to moderate orange pink to the south and east. The color of the alkali feldspar controls the color of the fresh rock. The alkali feldspar is perthitic microcline and is locally poikilitic with inclusions of plagioclase and biotite and a noticeable textural zoning. Wiborgite (rapakivi) texture is widespread and readily noticeable by the color difference between the two feldspars. Plagioclase grains are subhedral to anhedral plates up to 1 cm across and are white. They have normal oscillatory zoning of An_{21} to An_0. Biotite is the only varietal mineral and occurs as black flakes up to 5 mm across. It is locally altered to muscovite, chlorite, epidote, and rutile.

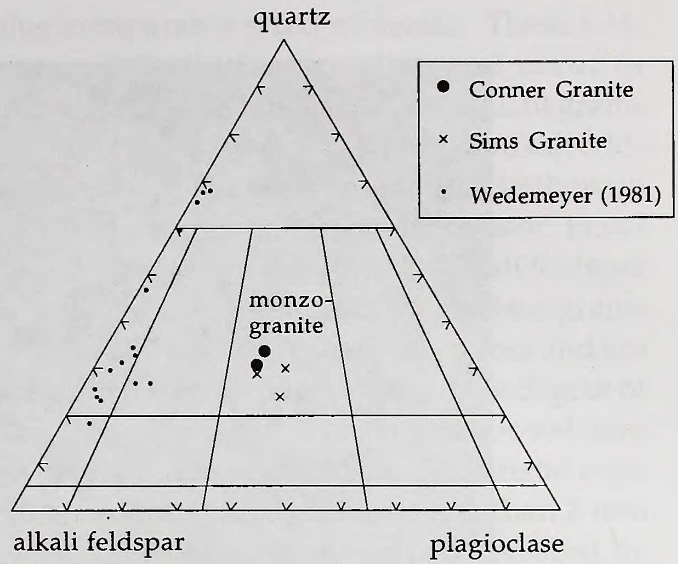


Figure 3. Triangular modal diagram of quartz - alkali feldspar - and plagioclase for the Sims pluton, NC granitoids.

Magmatic accessory minerals include apatite, monazite, and zircon. Apatite in rocks with abundant monazite have cores clouded by abundant 2-phase fluid inclusions. Opaque minerals are magnetite, exsolved hemo-ilmenite, columbite, pyrite, chalcopyrite, and pyrrhotite. Pyrrhotite occurs only as inclusions

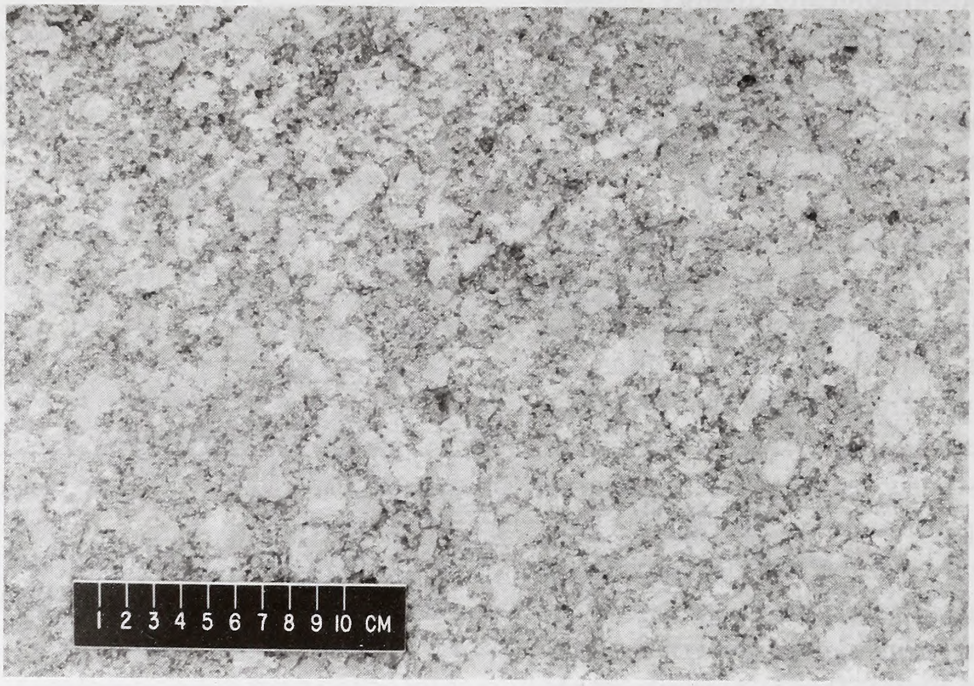


Figure 4a. Conner coarse-grained, inequigranular biotite granitoid. The large mineral grains are alkali feldspar megacrysts up 5 cm in a groundmass less than 1 cm.

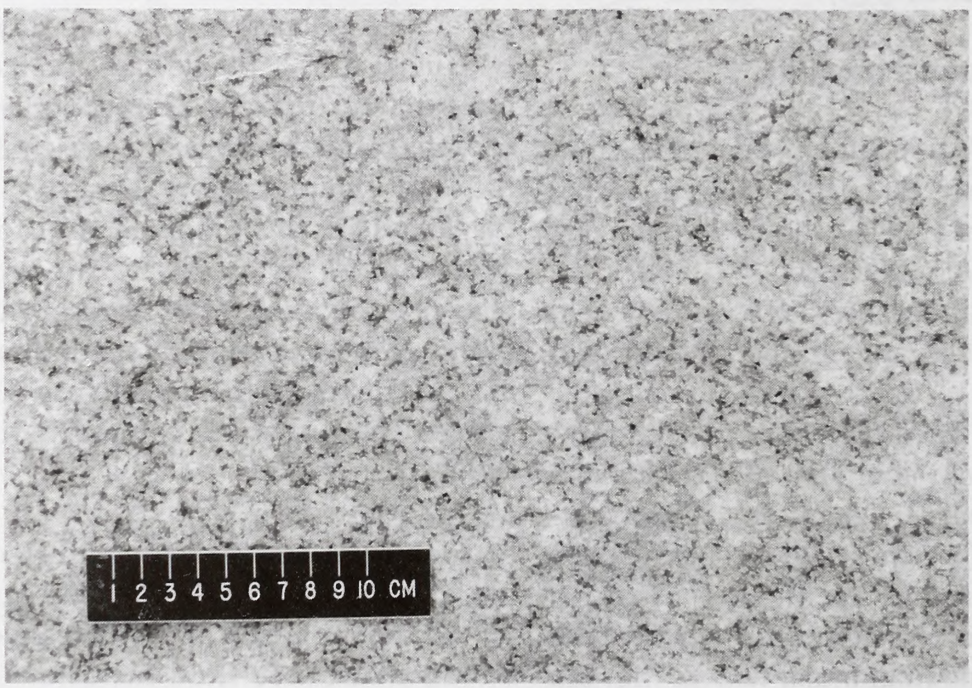


Figure 4b. The Sims coarse-grained, equigranular biotite granitoid.

in pyrite and exsolution intergrowths in chalcopyrite. Chalcopyrite occurs as matrix grains and inclusions in the silicate, oxide, and other sulfides. Pyrite and chalcopyrite also occur as fillings in fractures cutting across several different mineral grains. Carbonate, chlorite, epidote, fluorite, Nb-rutile, and muscovite are secondary accessory minerals.

Sims granitoid

Rocks in the center and northeastern corner of the pluton (fig. 2a) are also coarse-grained biotite granitoids, but the alkali feldspars are smaller than in the megacrystic granitoid. They are generally comparable in grain size with the other minerals. This gives the Sims granitoid a more equigranular appearance than the Conner granitoid (fig. 4b). It is assumed the Sims granitoid forms a continuous mass underlying the Coastal Plain sediments in that part of the pluton where they are the only exposed rock type.

Modal analysis show that the rocks are granites (table 1, fig. 3) with a color index (CI) < 5. The rocks lie in that area of the granite field designated monzogranite in the IUGS system (LeMaitre, 1989). Previous modal analyses by Wedemeyer (1981) showed these rocks as alkali feldspar granitoids with a wide modal scatter (fig. 3). The scatter resulted from point counting one thin section per sample, which was too small an area for the rock grain size. The name difference results from Wedemeyer's counting the albite zones of the plagioclase as alkali feldspar and the plagioclase saussuritization as muscovite.

The texture is hypidiomorphic granular with no discernible mineral alignment. Contrasting colors of the major minerals give the rock a mottled coloring in fresh samples, but weathered samples tend to be reddish. Alkali feldspar is generally no more conspicuous than the other comparably sized minerals. These feldspars are perthitic microcline and occur as subhedral to anhedral blocky and equant grains up to 1.5 cm across. Locally, tabular alkali feldspar grains up to 4 cm across similar to those in the inequigranular granitoids are present. However they are rare. Both types of alkali feldspar are pale red to grayish red. Plagioclase grains are anhedral and less than 5 mm across and are white to pale green depending on the degree of alteration. They have oscillatory normal zoning of An_{23} to An_0. Biotite is the varietal mineral and occurs as black flakes less than 2 mm across. The biotite is extensively replaced by muscovite, chlorite, epidote, fluorite, and rutile.

Magmatic accessory minerals include allanite, apatite, columbite, and zircon. Opaque minerals are magnetite, coarsely exsolved hemo-ilmenite, chalcopyrite, pyrite, and pyrrhotite. The hemo-ilmenite also contains intergrowths of rutile. Pyrrhotite occurs only as inclusions in magnetite and unmixed from chalcopyrite. Chalcopyrite occurs as inclusions in the silicates and oxides. The sulfide minerals are less abundant than in the megacrystic granitoids. Secondary accessory minerals are calcite, chlorite, fluorite, epidote, hematite, muscovite, Nb-bearing rutile, and titanite.

Fracture fillings and alteration zones in the Neverson Quarry were investigated by Barwick et al. (1978), who reported carbonates, chlorite, epidote, fluorite, hematite, muscovite, quartz, and pyrite as well as bornite, chalcocite, chalcopyrite, galena, molybdenite, and pyrite.

Relationship between the Conner and Sims granitoids

Field evidence for the possible relationship between the Conner and Sims granitoids was found only in the valley containing the west branch of Marsh Swamp, located in the north-

west corner of the Lucama quadrangle. There are outcrops of Conner granitoid on its southern length. The Conner granitoid in this area is inequigranular, containing about 25-33 modal % subhedral alkali feldspar megacrysts. Along the upper reaches of the stream, there are outcrops of Sims granitoid. Here the Sims granitoid is an coarse-grained, equigranular rock. An outcrop 0.1 km south of SR 1132 is a granitoid containing only about 10 modal % alkali feldspar megacrysts. This outcrop is the only one found at the contact between the two major facies of the pluton and contains features transitional between the two. The contact between the Conner and Sims granitoids is interpreted as a gradational contact.

Porphyritic granitoid

Near the southeast border of the pluton (SI-21) is a granitoid containing grains of perthitic microcline, plagioclase, quartz, and biotite up to 2 cm set in a fine-grained, nearly aphanitic matrix. The abrupt hiatal texture warrants the term porphyritic. Biotite is noticeably more abundant, and the CI is about 10. The alkali feldspars are blocky subhedral grains 0.5-2.0 cm across. The plagioclase occurs as tabular subhedral grains up to 1 cm across. Quartz occurs as equant grains up to 5 mm across in rough hexagonal dipyramids. These are most likely α-quartz pseudomorphs after β-quartz. Biotite occurs as rounded flakes 4 mm across. The matrix is comprised of the same minerals but of grains less than 0.5 mm across.

Claus and Smith (unpub. data, 1971) described several intervals of what they termed quartz porphyry within the Sims granitoid of the DDH 3 drillcore. Two intervals coincide for a distance of 30 feet. If these rocks are the same as those at location SI-21, then the porphyritic granitoid is a dike rock.

Aplite

Granitoid aplite occur locally in dikes up to 10 cm wide in both major granitoid lithologies of the pluton. The few surface exposures containing aplite would indicate that aplite dikes are relatively rare in the pluton. However, drillholes in the northwest area of the pluton encountered abundant aplite dikes (Claus and Smith, unpub. data, 1971). Thirty-one aplite dikes, occupying 1-6 inch intervals of core, were encountered in the 203-foot-deep DDH 1 drillhole, 15 aplite dikes were encountered in the 200-foot-deep DDH 3 drillhole, and 8 aplites were encountered in the 120-foot granitoid interval of DDH 1. By comparison, only 2 aplite dikes were encountered in the 2,577 feet core of the other 12 drillholes elsewhere in the pluton.

The aplite is white with a xenomorphic granular texture and grain size of $\leq$ 1 mm. CI is $<$ 2. Accessory minerals include biotite, muscovite, magnetite, hemo-ilmenite, and chalcopyrite locally intergrown with pyrrhotite and covellite.

Muscovite + quartz greisen

At the southeastern contact of the pluton, coarse-grained rocks of muscovite + quartz are found as outcrops and float boulders up to 4 m. Greisen occurs in a north-northwest-trending band up to 0.3 km wide extending about 1.5 km between State Roads 1131 and 1126 (fig. 2a). These rocks are the marginal greisen zone of Cook (unpub. data, 1972; 1972) and the quartz-muscovite hornfels of Farrar (1985). Because of their spatial association with the granitoid contact, they could form by alteration of either granitoid or country rocks. However, mapping and the Lindgren Exploration drillcores (Claus and Smith, unpub. data, 1971) shows that the greisen zone lies within the pluton. Three drill cores in an east-west traverse across the north-

ern end of the greisen zone (DDH 4, 5, and 6) encountered little greisen (Claus and Smith, unpub. data, 1971). An interval between 40- and 50-foot depth of DDH 6 was the largest. This greisen interval yielded an assay of 28 ppm Sn, the highest values found during exploration. A cluster of drillholes in the middle of the greisen zone (DDH 7, 8, 9, 10, 13, and 14) also encountered little or no greisen in most holes. DDH 7 contained a 1-foot interval of greisen at 250 feet whose Cu assay was 650 ppm, the highest value obtained during exploration. Significant greisen was located between 63-68 feet in DDH 8; between the intervals 132-152, 160-166, and 206-209 feet in DDH 10; and between 165-175 in DDH 13. Drillholes DDH 9 and 10 were located in an area of abundant greisen float. Two drillholes at the southeast contact of the pluton, where the greisen zone was mapped as adjacent to the wall rocks (DDH 11 and 12), encountered less than 2 feet of greisen.

Small occurrences of greisen are found in the northeast are of the pluton (Claus and Smith, unpub. data, 1971). A short (< 1 foot) interval of molybdenite-bearing greisen was encountered in the DDH 2 drillhole five feet in from the wall rock-pluton contact. The 10-foot section of core containing the greisen gave 127 ppm Mo, the highest values obtained during the exploration.

Muscovite occurs as unoriented grains up to 5 mm across. Rosettes of euhedral muscovite crystals occur in open vugs. The vugs are either an original feature or formed by the weathering of some mineral. The occurrence of limonite in some vugs indicates the later, probably pyrite. Locally the muscovite is color zoned. Quartz occurs intermixed with the muscovite or as separate veins. The quartz occurring with the muscovite is present as either disseminated granular masses or as 1-4 cm rounded to blocky grains with an appearance and distribution much like the alkali feldspars in the Conner granitoid. On the basis of this texture, the greisen is interpreted, in part, to have formed by replacement of the enclosing Conner granitoid. Feldspar is rare as are limonite pseudomorphs after earlier minerals. Chlorite was locally reported by Claus and Smith (unpub. data, 1971). Opaque minerals of the greisen are pyrite, chalcopyrite, and molybdenite (up to 10 mm masses) (Claus and Smith, unpub. data, 1971).

Veins

Through-out the area of the Sims pluton are scattered residual fragments of weathered vein material in the soil. This is invariably Fe-stained milky quartz, a ubiquitous feature of Alleghanian plutons. What sets the veins of the Sims pluton apart was the opportunity provided by the Lindgren Exploration Company drilling program to examine fresh samples (Claus and Smith, unpub. data, 1971).

Veins occupied up to 25 cm lengths of the drillcore. Massive, milky quartz is the dominant mineral. On the surface at DDH 12, quartz crystals up to 10 cm were found in the soil, indicating some quartz grew in open spaces. Calcite and calcite-bearing veins were found in the greisen zone. In a few drillholes, pyrite, with or without molybdenite, was noted as the mineral filling of hairline fractures. A quartz vein containing black tourmaline 1 cm long was encountered in DDH 10. Vein sulfide minerals include pyrite, chalcopyrite, molybdenite (up to 1.5 mm), sphalerite (with exsolved chalcopyrite), galena, arsenopyrite, pyrrhotite (contained within the pyrite), and chalcocite (replacing chalcopyrite). The occurrence of these minerals is sporadic, but they can comprise up to 2% by volume of the vein. The dominant sulfide mineral is pyrite. The only other mineral mentioned as occurring in the veins is chlorite.

Analysis of a sphalerite + galena-bearing vein within the Eastern slate belt at 115 feet in DDH 15 showed 520 ppm Pb, 500 ppm Zn, 90 ppm Cu; 7 ppm Sn, 3 ppm W, 2 ppm Mo, and no Au. The few other analyzed veins contained up to 60 ppm Cu, less than 1 ppm Mo (but one with 1,080 ppm Mo), and up to 16 ppm W, 10 ppm Zn, and 10 ppm Sn. Weathered quartz veins, or siliceous gossan, had uniformly higher base metal contents (up to 150 ppm Cu, 1,920 ppm Mo).

Wall rocks

Country rocks

Country rocks in the immediate vicinity of the Sims pluton are phyllites and metasiltstones. These rock types were included in the Smithfield formation described and mapped by Farrar (1985). They are considered to be of Late Proterozoic or Cambrian age with a greenschist facies metamorphic mineral assemblage of Taconic age. Detailed mapping of the Middlesex (Carpenter et al., 1995), Stancils Chapel (Carpenter et al., 1995), and Lucama (Hoffman et al., unpub. data, 1995) quadrangles shows that the pluton is emplaced in a sequence of laminated argillites and massive siltstone (fig. 2b). Phyllites are distinguished on the basis of well defined fissility, sheen, and abundant phyllosilicates. They range in color from grayish green through grayish red purple and tend toward brown when weathered. Metasiltstones are more granular, with visible mineral grains and weak foliation. They are grayish green. Both rock types contain the same mineral assemblage: muscovite + chlorite + quartz + opaques ± epidote. Both rock types are crosscut by quartz veins. Measurable foliations of the country rocks are phyllosilicate mineral alignments which appear to subparallel rock cleavage and compositional layering. The general trend is N.10°E. - N.20°E. and, within the sparse distribution of observations, appear undisturbed by emplacement of the Sims pluton (fig. 2b).

Contact metamorphic aureole

Several mapping traverses across the granitoid - wall rock contact located only one surface exposure of contact metamorphic effects in the aureole (SI-25). This was within 0.2 km or less of the contact. This hornfels is distinguished in the field from the phyllites of the country rocks by its dark greenish gray color and 1 mm round pyrite porphyroblasts. The mineral assemblage is biotite + muscovite + quartz.

The Lindgren Exploration Company encountered several contact metamorphic effects in holes drilled to cross the pluton - wall rock contact (Claus and Smith, unpub. data, 1971). Within two meters of the granitoid contact in DDH 2, the Eastern slate belt phyllites gave way to a spotted biotite-muscovite hornfels with 10% pyrite and a 1 inch zone of 3 mm garnets with epidote and molybdenite. DDH 15 was located within 50 feet of the pluton contact, but did not intersect the granitoid when drilling stopped at 270 feet. The hole started in greenish gray, delicately banded argillite which became more micaceous, massive, and darker with depth. Garnet-bearing quartz-rich rocks appeared, starting at 100-foot depth. These changes were interpreted as an effect of increasing contact metamorphism. Two calc-silicate garnet tactite zones were encountered between 243-247 feet.

Farrar (1985) described a pelitic xenolith from the Neverson Quarry with the assemblage biotite + andalusite + fibrolite + quartz + muscovite. Re-examination of the sample (F7-163-2) shows it is a fine-grained, xenomorphic granular rock with banding defined by dark oblate poikiloblasts up to 3 mm across. In addition to the reported mineral assemblage, the

rock also contained plagioclase and two textural occurrences of muscovite. Muscovite occurs as flakes equal in size to the biotites and as fine-grained aggregates which form the poikiloblasts. The poikilitic porphyroblasts may have originally been cordierite.

Wilson (1979) mapped as hornfels the rocks along Contentnea Creek south of the Sims pluton in a rectangular area 1.5 km wide and extending to the county line up to 4 km away from the contact. These rocks are metasiltstones and, while having a massive texture, do not have a mineralogy or texture indicative of contact metamorphism. These rocks are a lithologic unit within the country rocks which can mapped on a regional basis (fig. 2b).

GRANITOID COMPOSITIONS

Sims Pluton

Major and trace element composition of the Conner and Sims granitoids are reported in tables 2 and 3. Various calculated petrochemical parameters and CIPW norms are included in table 2.

The granitoids of the Sims pluton span a small compositional range. The silica contents of the rocks only range from 73.56 to 74.97 wt.%, and the other elements have comparable compositional ranges. There are small, but systematic major element differences between the Conner and Sims granitoids. The Conner granitoid contains more Si and less Ti, Al, Fe, Mg, Ca, Na, and K than the Sims granitoid (table 2). Most trace element compositions of the two facies overlap, but there are important differences. The Conner granitoid contains more Li, Be, Rb, Nb, Cs, Ta, U and less Sr than the Sims granitoid (table 3).

The Conner and Sims granitoids are subalkaline on the basis of $Na_2O + K_2O$ vs. silica, with $K_2O > Na_2O$. The granitoids are leucocratic, and $TiO_2 + Fe_2O_3 + MgO + MnO$ is less than 2.80 wt.%. They are iron-rich, with an average cation Fe/(Fe+Mg) ratio of 0.659 (table 2). There is wide scatter of ferrous and ferric iron contents, and the cation $Fe^{+3}/(Fe^{+2} + Fe^{+3})$ ratio is 0.322-0.853. The granitoids extend into the calc-alkaline field on an AFM plot (Irvine and Baragar, 1971); however, the rocks are too felsic, and their compositional range too limited, to make this distinction meaningful. They span the metaluminous-peraluminous boundary with a range of A/CNK (molecular Al_2O_3/[$CaO + Na_2O + K_2O$]) values from 0.994 to 1.025. However, all rocks have normative corundum (table 2).

A lower-crust normalized plot of selected elements is given in figure 5. The lower crust was chosen for normalization because it is a likely source for the Alleghanian granitoid

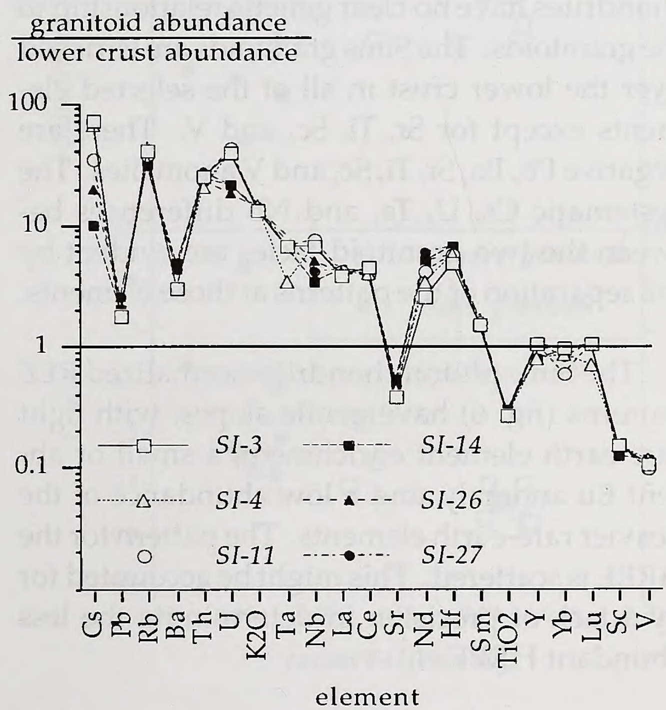


Figure 5. Lower-crust normalized diagram for the Sims pluton, NC. Data is from Table 3. Normalizing values from Taylor and McLennan (1985).

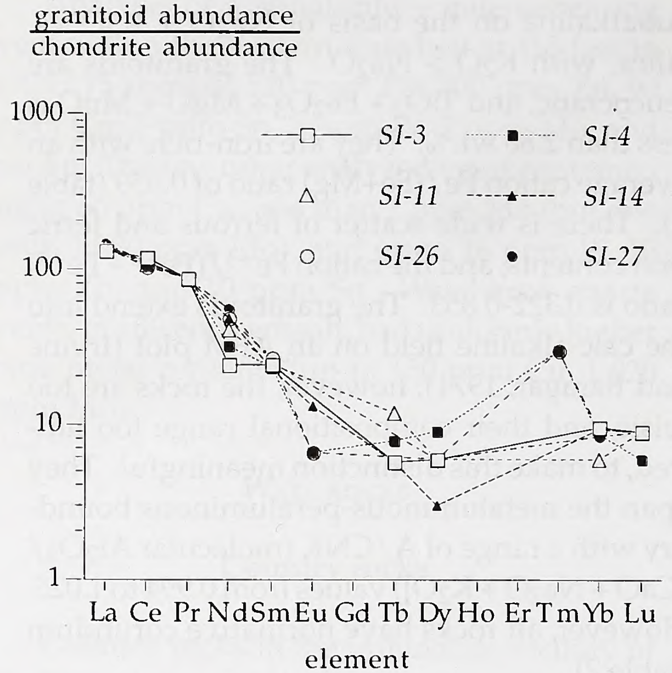


Figure 6. REE chondrite-normalized diagram for the Sims pluton, NC. Data is from Table 3. Normalizing REE values from Nakamura (1983).

magma whereas MORB, primitive mantle, or chondrites have no clear genetic relationship to the granitoids. The Sims granitoids are enriched over the lower crust in all of the selected elements except for Sr, Ti, Sc, and V. There are negative Pb, Ba, Sr, Ti, Sc, and V anomalies. The systematic Cs, U, Ta, and Nb differences between the two granitoid facies are evident by the separation of the patterns at those elements.

The Sims pluton chondrite-normalized REE patterns (fig. 6) have gentle slopes, with light rare-earth element enrichment, a small or absent Eu anomaly, and a low abundance of the heavier rare-earth elements. The pattern for the HREE is scattered. This might be accounted for by a lack of precision in determining the less abundant HREE.

Comparison with other Alleghanian Granitoids

The rocks of the Sims pluton have, for the most part, compositions that fall within the range of compositions of the Alleghanian granitoids of the southern Applachians. The mean composition, and standard deviation, are included in tables 2 and 3. These values are reported by Speer and Hoff (in press) and are compiled from up to 609 rock analyses for some elements. The Sims pluton granitoids are more siliceous than the average. Speer and Hoff (in press) found that a number of elemental concentrations varied linearly with silica content. Many of the differences of the Sims granitoids from the averages of tables 2 and 3 result from this effect. However, a few differences exceed this silica compositional effect. The Conner granitoids have greater amounts of S, Nb, Cs, and U than most Alleghanian granitoids, even those granitoids as siliceous as the Sims.

MINERALOGY

Mineral compositions were obtained from 9 Conner granitoid, 6 Sims granitoid, 2 greisen, and 1 porphyritic granitoid samples. Also included in the work were 4 polished sections of samples originally used by Farrar (1985) to describe the Sims pluton.

Biotite

Biotites of the Sims granitoid are more magnesian, F-rich, and less aluminous than those in the Conner, but there is a continuous compositional gradation between them (table 4, fig. 7 and 8). These compositional variations can be related by four solid solutions: Tschermak [$^{iv}Al^{vi}Al(Fe,Mg)_{-1}Si_{-1}$], F-OH [$OHF_{-1}$], and Fe-Mg [$MgFe_{-1}$] exchanges, and a degree of solid solution with the dioctahedral micas (fig. 9).

White Mica

The white micas in the Sims pluton are dominantly muscovite-phengite solid solutions

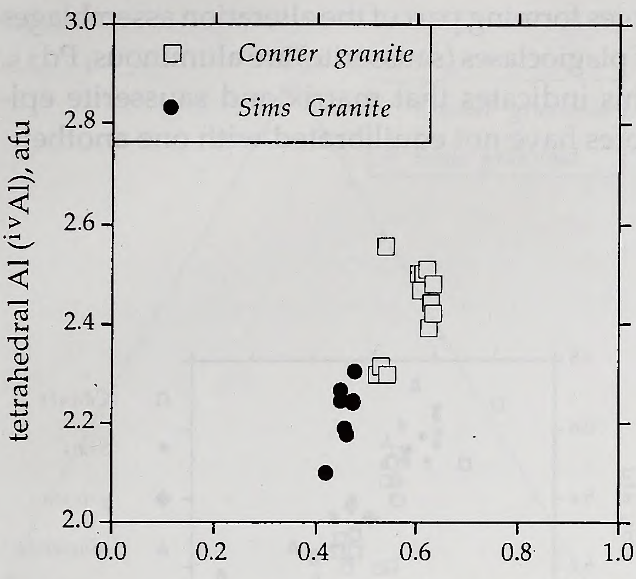


Figure 7. Sims pluton, NC biotite compositions projected onto the phlogopite-annite-eastonite-siderophyllite field and differentiated by granitoid. Biotite compositional data from table 4.

with minor trioctahedral substitution (table 5, fig. 9). There are small compositional differences among the muscovites depending on occurrence with lithology and in an individual sample. Muscovites in plagioclase (sausserite) are sodic, but have less Fe+Mg, Ti, and F than the matrix muscovites (fig. 10). Greisen muscovites are more sodic than the granitoid matrix muscovites.

X-ray diffraction analysis of the greisen muscovites show them to be the $2M_2$ polymorph (Claus and Smith, unpub. data, 1971). Spectrographic analysis of the greisen showed that Li was present in quantities of up 100 ppm (Kiff and Schell, unpub. data, 1969). This indicates that the Li-bearing mica, zinnwaldite does not occur in any significant degree, either as a separate phase or as a component of the mica.

Feldspars

Microprobe analyses show that the plagioclases have a compositional range of An_{25} to An_0 and that the perthites are intergrowths of albite and K feldspar of average composition Or_{96} (table 6, fig. 11).

Oxide Minerals

The rhombohedral oxides are ilmenite and hematite. They occur as intergrowths, indicating they have exsolved from a higher-temperature hemo-ilmenite solid solution. Ilmenite is close to end-member composition on the ilmenite-hematite join, whereas hematite has a significant ilmenite solid solution (tables 7 and 8, fig. 12). However, the ilmenite has up to 32 mol % substitution of the pyrophanite component ($MnTiO_3$), though most have about 20% (table 7). The spinel phase is magnetite with nearly the ideal composition (table 9). A brown

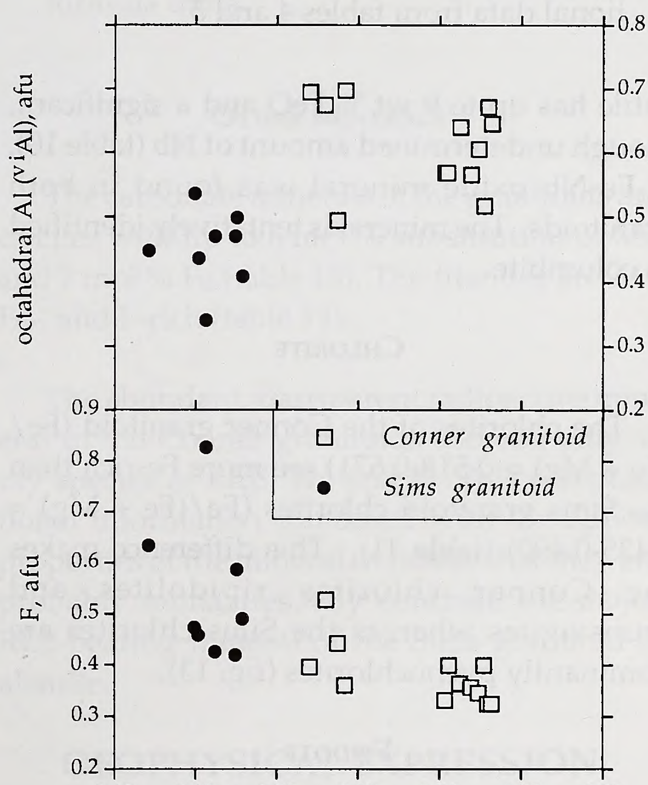


Figure 8. Sims pluton, NC biotite variation diagrams for ^{vi}Al, Fe, Mg, and F with Fe/(Fe + Mg). Compositional data from table 4. afu = atomic formula units.

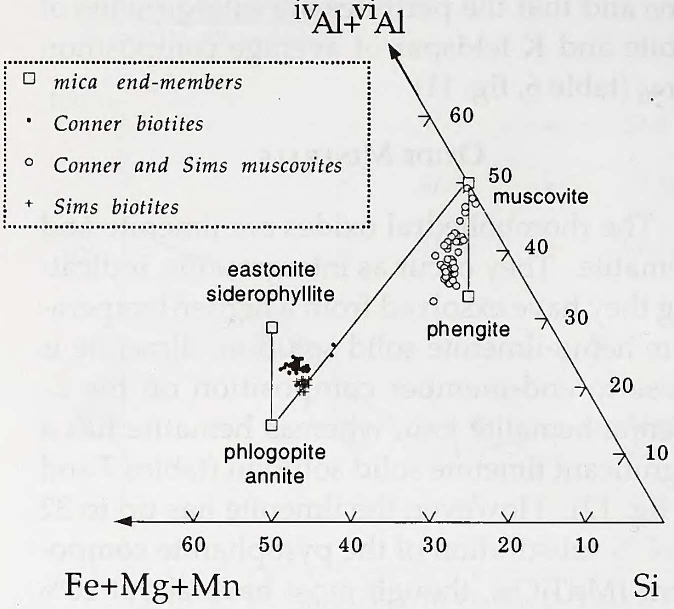


Figure 9. Sims pluton, NC mica compositions plotted on a Fe+Mg+Mn—Al—Si (atomic proportions) diagram. Mineral compositional data from tables 4 and 5.

rutile has up to 9 wt % FeO and a significant, though undetermined amount of Nb (table 10). A Fe-Nb oxide mineral was found in both granitoids. The mineral is tentatively identified as columbite.

Chlorite

The chlorites of the Conner granitoid (Fe/(Fe + Mg) = 0.518-0.671) are more Fe-rich than the Sims granitoid chlorites (Fe/(Fe + Mg) = 0.435-0.490) (table 11). This difference makes the Conner chlorites ripidolites and brunsvigites whereas the Sims chlorites are dominantly pycnochlorites (fig. 13).

Epidote

Matrix epidotes in both granitoids of the Sims pluton have narrow compositional ranges. The pistacite component is $Ps_{27.4}$-$Ps_{31.0}$ with Mn contents corresponding to a piemontite component between $Pd_{0.4}$ and $Pd_{0.9}$ (table 12). Epidotes forming part of the alteration assemblages of plagioclases (sausserite) are aluminous, $Pd_{3.5}$. This indicates that matrix and sausserite epidotes have not equilibrated with one another.

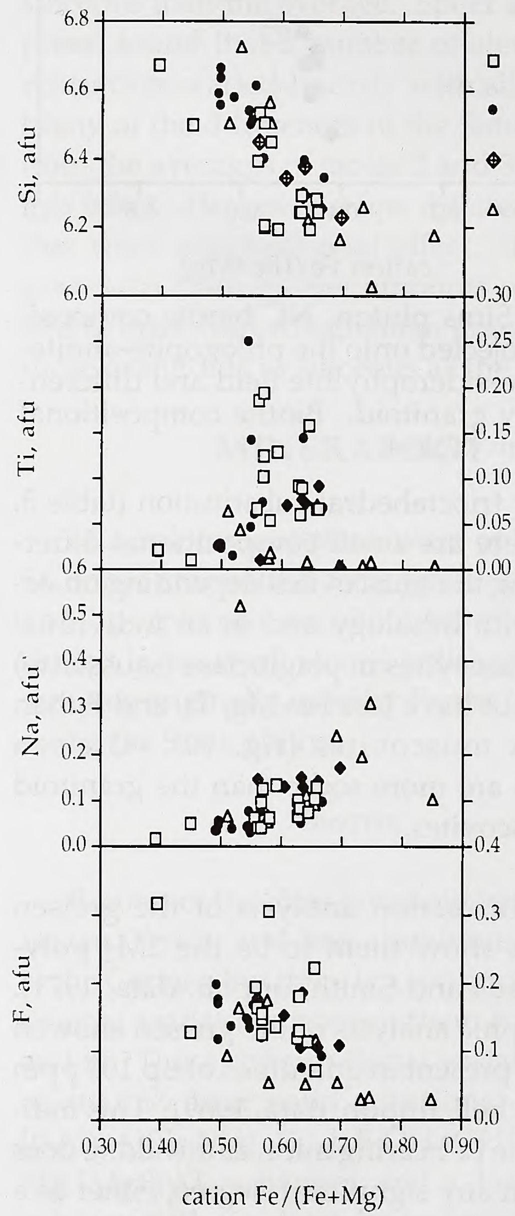


Figure 10. Sims pluton, NC muscovite variation diagrams for ^{vi}Al, Fe, Mg, and F with Fe/(Fe + Mg). Muscovite compositional data from table 5. afu = atomic formula units.

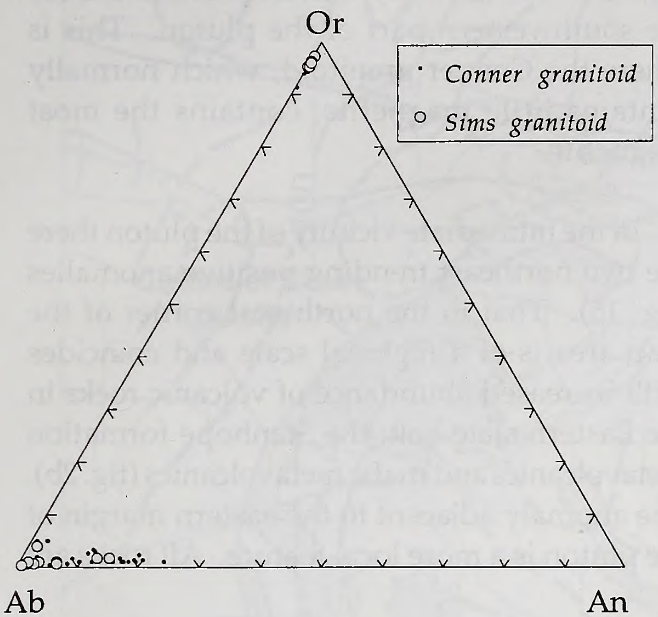


Figure 11. Sims pluton, NC feldspar compositions plotted on the ternary end-member Or (K) - Ab (Na) - An (Ca) diagram. Feldspar compositional data from table 6.

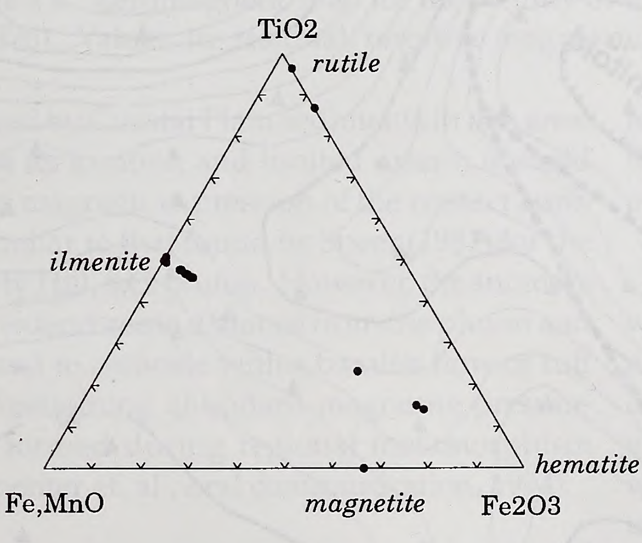


Figure 12. Sims pluton, NC oxide compositions projected onto a cation Ti—Fe^{+2}, Mn—Fe^{+3} ternary diagram. Mineral compositional data from tables 7, 8, 9, and 10.

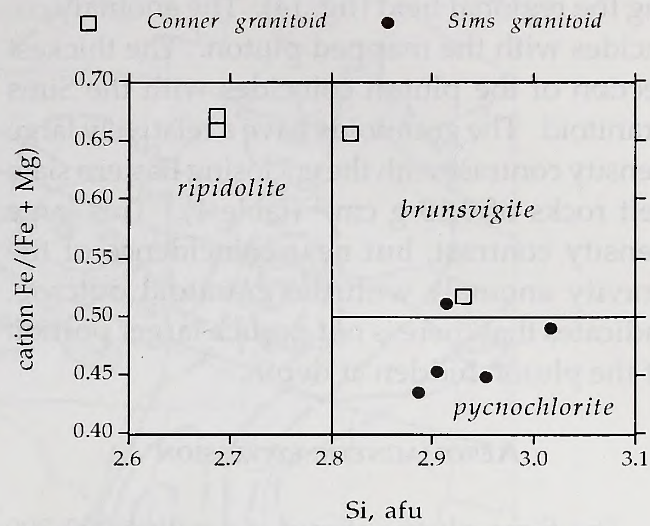


Figure 13. Sims pluton, NC chlorite compositions projected onto Si *vs.* cation Fe/(Fe+Mg) bivariate diagram. Mineral compositional data from table 11. afu = atomic formula units.

Other Minerals

The carbonate minerals of the granitoids are calcites with up to 6 mol % substitution of Mn and 2 mol % Fe (table 13). The titanites are Al-, Fe-, and F-rich (table 14).

The abundant, transparent radioactive mineral in the Conner granitoids showed only x-ray spectra of REE, Th, and P. This compositional information combined with the optical properties of the mineral indicates that they are probably monazites. By contrast, the major REE-bearing mineral of the Sims granitoid is allanite.

GEOPHYSICAL EXPRESSION

Gravity expression

The Sims pluton is evident on large-scale gravity maps (Haworth et al., 1980; Lawrence, 1996) as a negative -40 mgal anomaly perturb-

ing the regional field (fig. 14). The anomaly coincides with the mapped pluton. The thickest section of the pluton coincides with the Sims granitoid. The granitoids have a relatively large density contrast with the enclosing Eastern slate belt rocks of 0.13 g cm^{-3} (table 1). This large density contrast, but near coincidence of the gravity anomaly with the granitoid outcrop, indicates that there is not a much larger portion of the pluton hidden at depth.

Aeromagnetic expression

The Sims pluton shows a positive 200-300 gamma anomaly compared to the regional field (fig. 15). The anomaly is most pronounced for the southwestern part of the pluton. This is where the Conner granitoid, which normally contains little magnetite, contains the most magnetite.

In the immediate vicinity of the pluton there are two northeast trending positive anomalies (fig. 15). That in the northwest corner of the map area is of a regional scale and coincides with increased abundance of volcanic rocks in the Eastern slate belt; the Stanhope formation metavolcanics and mafic metavolcanics (fig. 2b). The anomaly adjacent to the eastern margin of the pluton is a more local feature. All rocks are

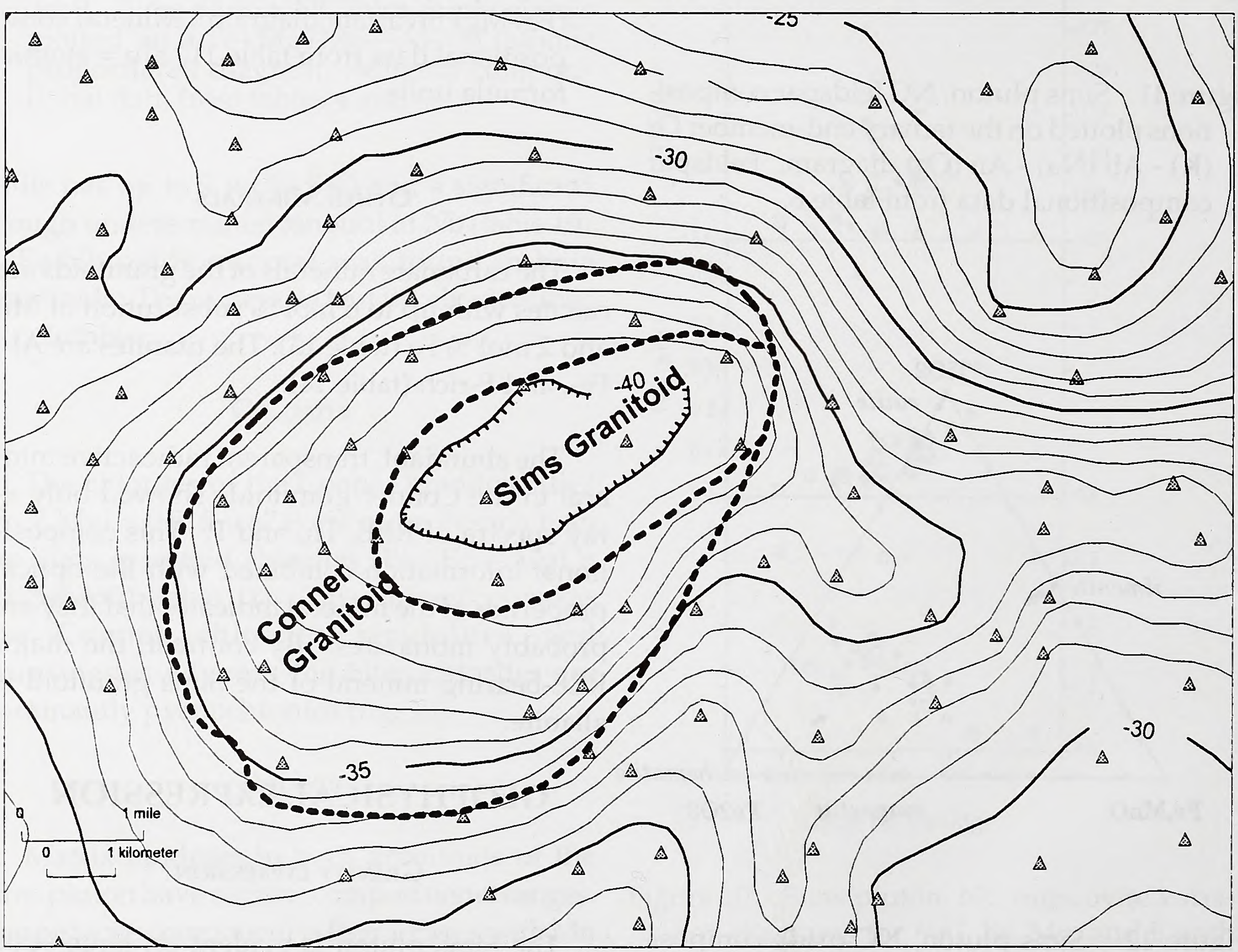


Figure 14. Bouguer gravity anomaly map for the Sims pluton and vicinity (Lawrence, 1996). Shaded triangles indicate location of the observations.

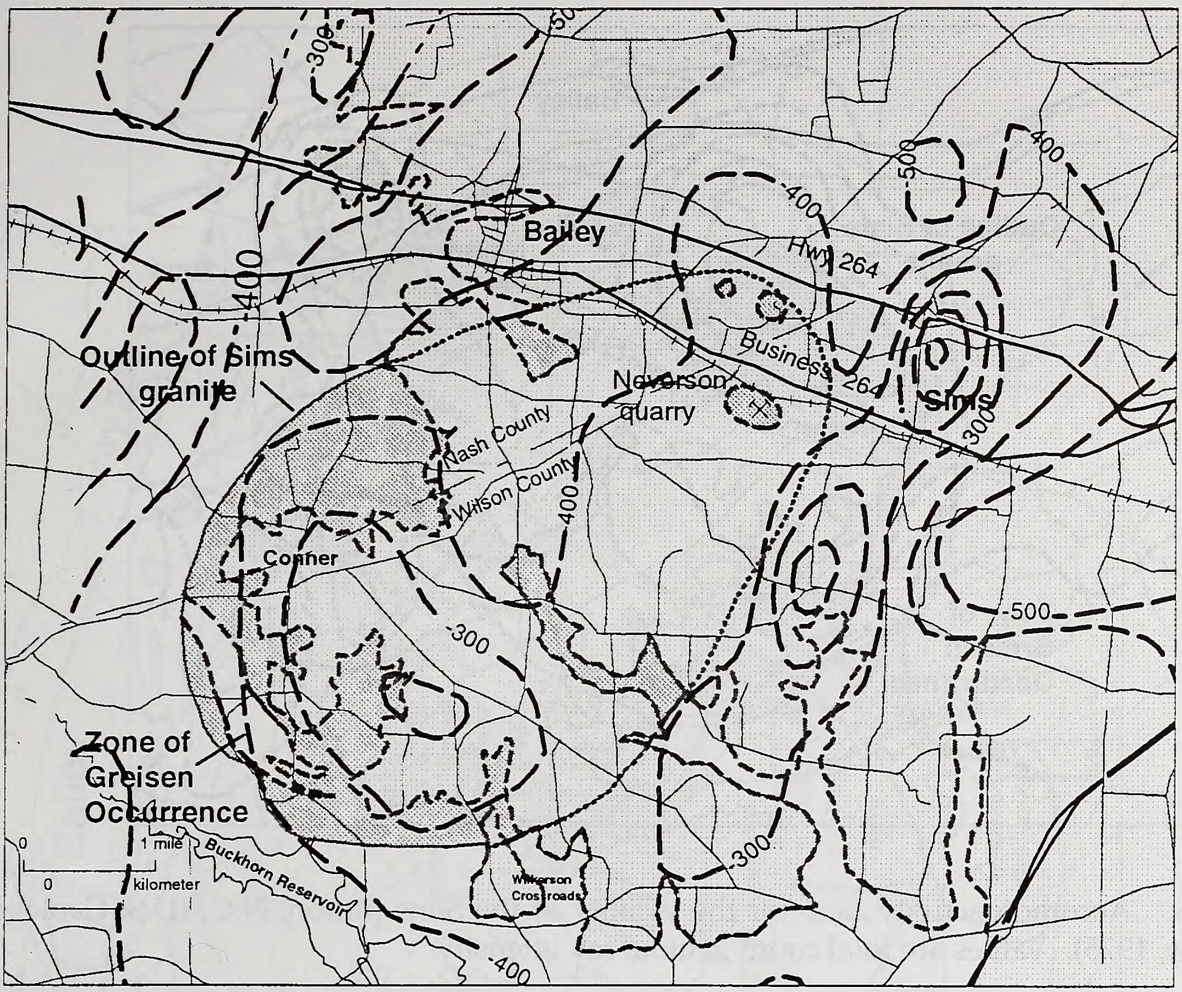


Figure 15. Aeromagnetic map for the vicinity of the Sims pluton, N.C. (U. S. Geological Survey, 1976). Values are residual, negative magnetic intensity in gammas.

covered by Coastal Plain sediments in this area. Given its location and limited extent, it could be the magnetic expression of the contact aureole similar to that found by Speer (1981) for the Liberty Hill, S.C. pluton. However, the anomaly does extend some distance from the pluton and is found to coincide with a basaltic flow or tuff unit containing abundant magnetite presumably formed during regional metamorphism (Carpenter et. al., oral communication, 1994).

Aeroradiometric expression

The Sims pluton coincides with a positive 200-800 total gamma ray count anomaly as compared to the regional field (fig. 16). This is readily explained by the higher radioactive element content (K, U, Th) of the granitoids as compared to the enclosing Eastern slate belt.

The anomaly has two, well-defined maxima within it. The maximum at the northwest corner of the pluton coincides with an area of abundant, exposed outcrops of the high U Conner granitoid and aplite dikes. Away from this area within the pluton, the outcrop and number of aplite dikes are less abundant and the pluton becomes increasingly covered by Coastal Plain sediments. The reason for the radiometric maximum at the northeastern corner of the Sims pluton is less clear. This is the location of the Neverson Quarry. This single large exposure

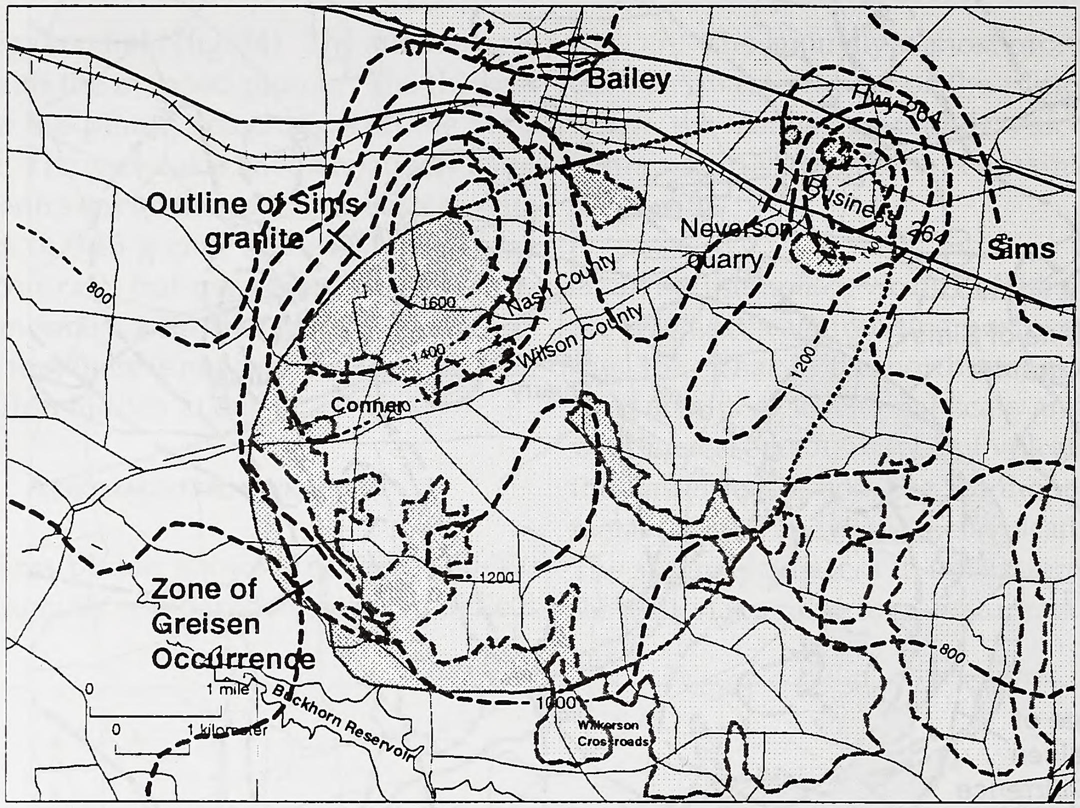


Figure 16. Aeroradioactivity map for the vicinity of the Sims pluton, N.C. (U.S. Geological Survey, 1975). Values are total count gamma ray intensity.

of exposed Sims granitoid might represent sufficient contrast with the covering Coastal Plain sediments to cause the maximum. The maximum could be associated with a local concentration of radioactive minerals within the heavy mineral deposits of the Coastal Plain sediments.

SOIL AND GROUNDWATER RADON

The soil-gas and groundwater radon contents over the Sims pluton and wall rocks were reported by Speer (unpub. data, 1992, 1994). Radon contents of the soil-gas and groundwater of the overlying Coastal Plain rocks containing the Bailey South heavy-mineral deposit are reported by Speer (unpub. data, 1994). Locations of the sample sites and soil-gas radon concentrations are shown in Figures 17 and 18. The comparable diagrams for the groundwater radon are figures 19 and 20. Numerical results are in tables 15 and 16.

The median soil-gas radon associated with the granitoid is 2,289 pC/l (N=24). These soil-gas radon contents were among the highest sampled over granitoids in the southern Appalachians. This is expected because the Sims plutons also is among the highest U granitoids in the southern Appalachians with an average of 11.13 ppm for the Conner granitoid and 5.45 ppm for the Sims granitoid. The average uranium content of 600 Alleghanian granite samples from the southern Appalachians is 4.9 ppm U (Speer, unpub. data. 1994). Most high soil-gas radon values of the granitoid are located in the northwestern corner of the pluton (fig. 18) which is the same location of a positive aeroradiometric anomaly (fig. 16). By contrast, the soil-gas radon contents over the surrounding Eastern slate belt is 1,192 pC/l (N = 8).

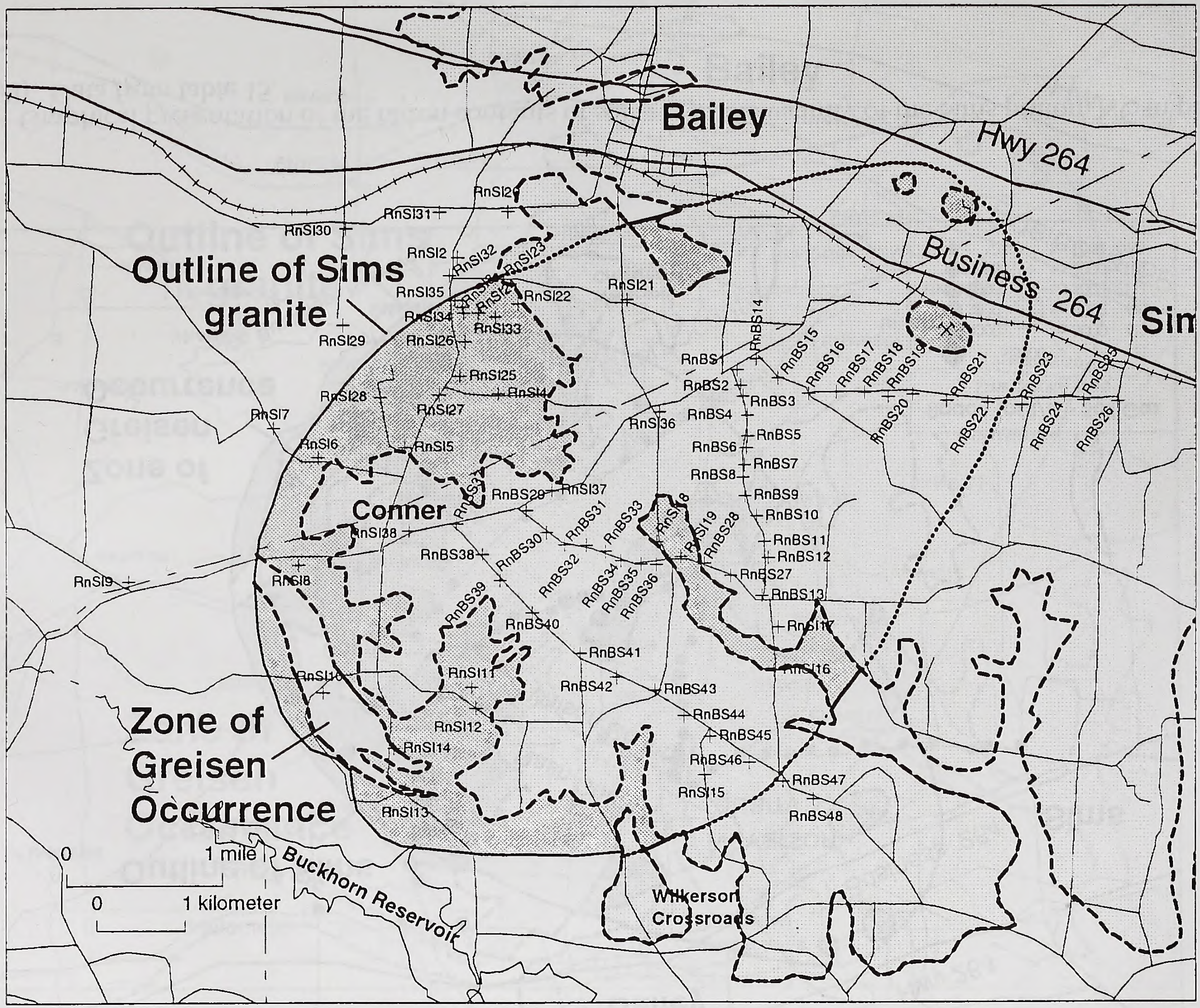


Figure 17. Soil-gas sample location map in the vicinity of the Sims pluton, NC. Samples starting with RnSi were collected specifically to investigate the radon contents of soil gas over the granitoids and Carolina slate belt. Samples designated RnBS were collected to investigate the soil-gas radon contents of the Bailey South heavy mineral deposit within the overlying Atlantic coastal plain.

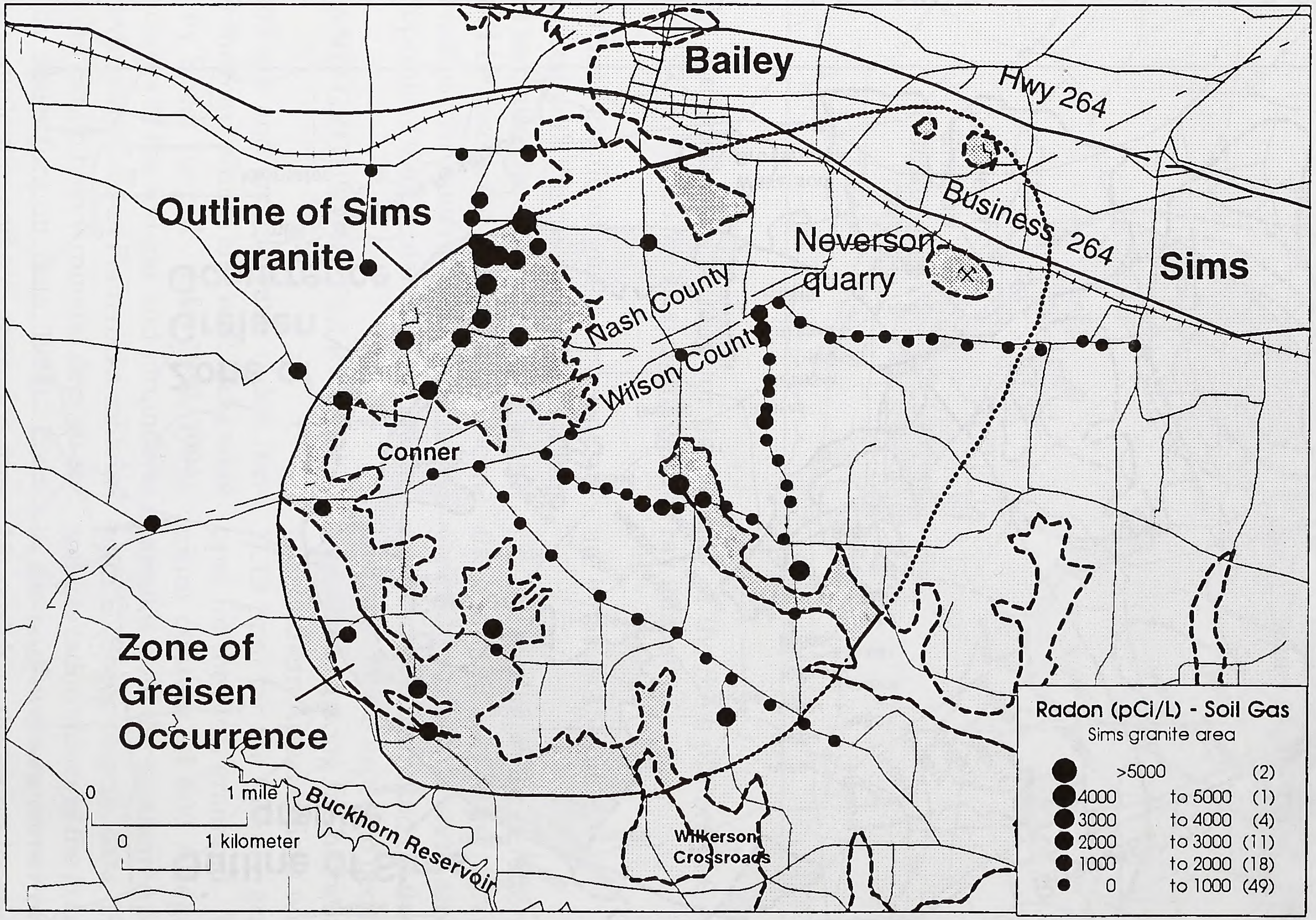


Figure 18. Graphical presentation of the radon contents of soil gas in the vicinity of the Sims pluton, NC in picroCuries per liter (pC/l). Data from table 15.

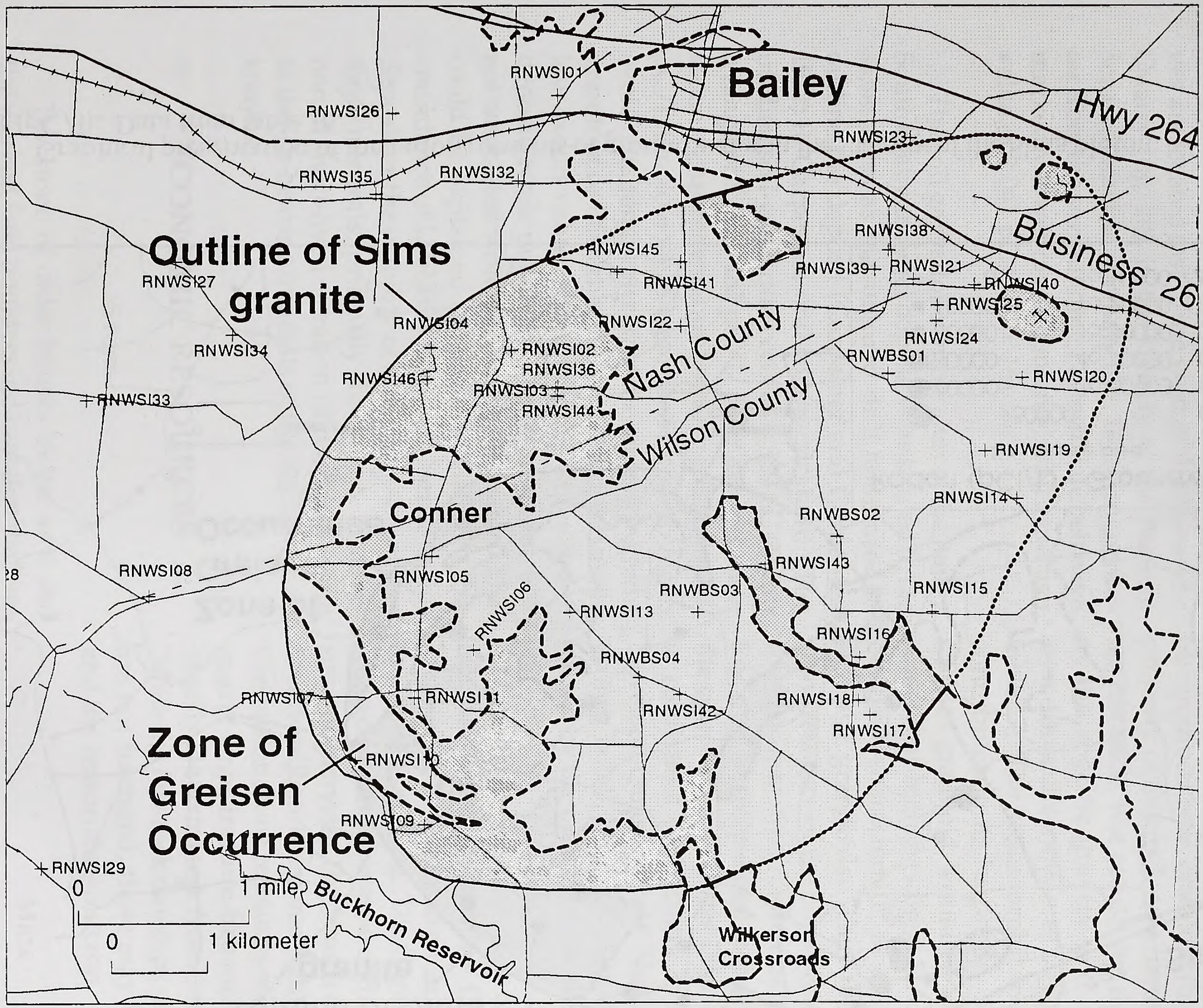


Figure 19. Groundwater sample location map in the vicinity of the Sims pluton, NC. Samples starting with RnWSi were collected specifically to investigate the groundwater of the granitoids and Eastern slate belt. Samples designated RnWBS were collected to investigate the groundwater of the Bailey South heavy mineral deposit within the overlying Atlantic coastal plain.

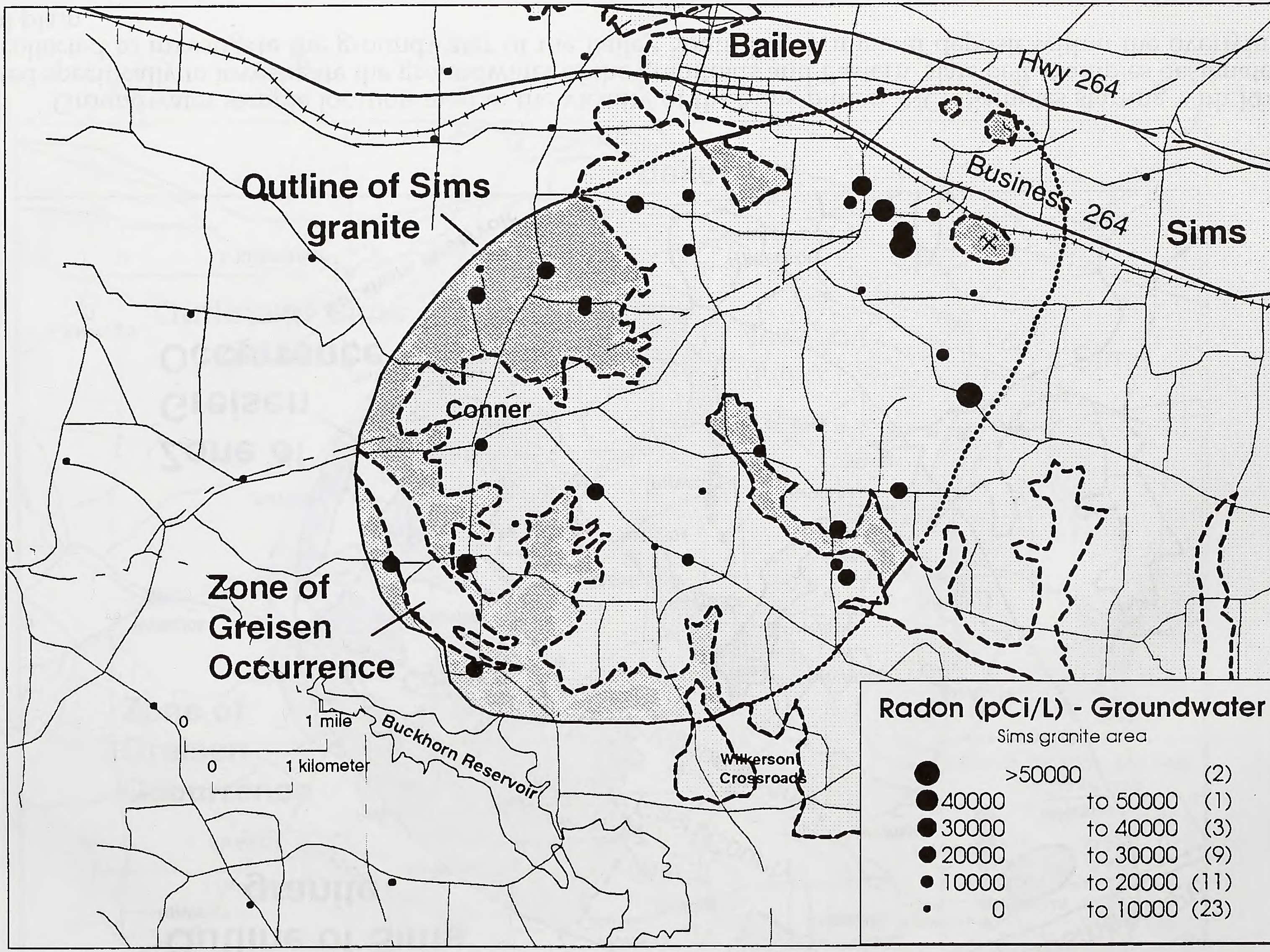


Figure 20. Graphical presentation of the radon contents of groundwater in the vicinity of the Sims pluton, NC in picroCuries per liter (pC/l). Data from table 16.

The groundwater radon contents of the Sims pluton, NC are high. The median value is 20,251 pC/l with a range of 2,970 to 65,895 pC/l (N = 29). There is no discernible difference in groundwater radon concentrations between the Conner and Sims granitoids. The highest values are located just to the west of the Neverson Quarry (fig. 20), in the vicinity of the positive aeroradiometric anomaly (fig. 16). Groundwater from the surrounding Eastern slate belt have markedly lower radon contents, with a median value of 2,041 pC/l (N = 16).

The soil gas radon sample sites of the Bailey South heavy-mineral deposit were located in the same areas as the augured drill holes used to outline the deposit (Carpenter and Carpenter, 1991; R. Carpenter, oral communication). The median soil-gas radon content is 323 pC/l with a range of 57 to 1482 pC/l. Four groundwater radon measurements are between 632 and 6,780 pC/l. Shallow wells were used for sampling to avoid obtaining water from the underlying Sims granitoid or Eastern slate belt. These relatively low radon values show that the Bailey South deposit, while possibly a gamma-ray source, is not associated with high soil gas ^{222}radon. This could be explained by either a relatively low abundance of U-bearing heavy minerals in this deposit or the inability of radon to escape from these minerals, primarily the zircon. Production of short-lived ^{220}radon (thoron) as a result of the Th-bearing minerals of the deposit is unknown.

ECONOMIC RESOURCES

Stone

The stone of older houses in the area and the worked field boulders indicate that the Sims pluton has been quarried on a small, but widespread basis for dimension stone for some time. Commercial quarrying for stone began in 1917 at the Neverson Quarry (Councill, 1954). The quarry is currently operated for crushed stone by the Nello Teer Company.

The Neverson Quarry is located at the northeast corner of the pluton within the equigranular Sims granitoid (fig. 2a). The noted property of this rock is its hardness. Los Angeles Abrasion Test results for the stone, as well as the specific gravity and sodium sulfate soundness of various size fractions are given in table 17. The xenomorphic texture of the rock contributes to its hardness. The megacrystic Conner granitoid would be expected to have somewhat higher (softer) L.A. wear numbers of 40-60, characteristic of more automorphic granular granitoids. Thus the best aggregate stone resource of the Sims pluton is confined to the Sims granitoid. Outcrops of the Sims granitoid may be steep-sided monadnocks buried by the surrounding Coastal Plain sediments. This is confirmed by drilling in the case of the Neverson Quarry by the Nello Teer Company (James Izzell, oral communication) and suspected by the occurrence of the other outcrops.

Stone from other sources, but similar in texture and color to both the Conner and Sims granitoids, is widely used as dimension stone or decorative facing. The Conner has a coarsely colored mottling because of the large alkai feldspar megacrysts. The Sims is even-grained and locally brilliantly colored light to moderate red. Dimension stone resources require an ability to quarry large, fracture-free rock. This cannot be readily determined from surface outcrops. While the few rock outcrops of the Sims pluton are not fractured, these may be the exception and the reason they outcrop.

Mica

The rocks of the greisen zone of the Sims pluton comprise 40-100 modal % muscovite.

The remainder is dominantly quartz. The area of abundant greisen outcrop and float is 1.5 km long and up to 0.3 km wide. Both drilling and examination of surface float show that greisen does not constitute all of the bedrock in this large area, but they do indicate it is abundant and can be the dominant rock in bodies up to 0.2 km in size. This is a potential mica resource and was evaluated by the N. C. Geological Survey and the Minerals Research Laboratory, Asheville, NC (Carpenter, et al., 1995). The mica, which is high in potassium as compared to other sources, would make excellent flux coating of welding rods and may be suitable for dusting rubber compounds. Drawbacks to this mica are the high grinding hardness, low brightness, and high bulk density. The latter two could be improved by more efficient grinding to finer particle sizes. For other uses the mica could be mixed with material from other sources to meet specifications. Given the mineralogy of the greisen and the occurrence of greisen within the Conner granitoid, potential by-product minerals include quartz and feldspar.

Base Metals

The Sims pluton was extensively investigated for possible base metal resources by the Lindgren Exploration Company of Wazaya, Minnesota between 1965 and 1979. The metals of interest were copper, molybdenum, tin, and tungsten. The program began with a literature research and scouting of the southeastern United States that lead to the conclusion that there was the potential for discovery of economic mineral deposits by the use of geochemical and geophysical exploration techniques (Lindgren, unpub. data, 1967). Reconnaissance geochemical sampling of the soils of the Carolina slate belt in Virginia and North Carolina by Kiff (unpub. data, 1968) located several areas with anomalous Cu and Mo, including the area of the Sims pluton. Given here is a summary of investigations by the Lindgren Exploration Company of what initially was called the Conner anomaly. The anomaly was eventually concluded to result from a porphyry-type mineralization of the Sims (= Conner) pluton.

Following up on the reconnaissance discovery of the Conner anomaly, Cu and Mo analyses of 850 soil and 70 rock samples and geological mapping at a scale of 1:1000 were done by Kiff and Schell (unpub. data, 1969). They recognized the presence of the Atlantic Coastal Plain and sampled at locations or depths to 10 feet to avoid the sediment cover. Kiff and Schell identified four favorable areas in the vicinity of the Sims pluton: [1] disseminated molybdenite mineralization in the Neverson Quarry, referred to in company reports as the northeast area, [2] a greisen zone along the western margin of the pluton containing anomalous W and Mo and referred to as the southwest area, [3] anomalous Mo values at the granitoid-slate belt contact in the vicinity of the junction of State Roads 1100 and 1104 and referred to as the northwest area, and [4] anomalous Cu mineralization in sericitized and silicified Eastern slate belt rocks along the western contact of the pluton. Only the first three areas were pursued in subsequent exploration work. Vertical sampling of the weathering profiles of the granitoids showed that Mo decreased and Cu remained unchanged with depth. Vertical sampling profiles over the Eastern slate belt showed an equal number of increases and decreases of Cu content with depth. The soil Cu and Mo data were analyzed by the log-probability method of Lepeltier (Cook, unpub. data, 1972). Soil samples collected over the granitoid had average Cu backgrounds of 15 ppm and a determined anomalous threshold of 35 ppm, with 3% of the samples being at this level or higher. Average Mo backgrounds were 1 ppm and a determined anomalous threshold of 5 ppm, with 6% of the samples being greater than this amount. Sum-

mary maps of the Lindgren geochemical results are shown in figures 21 (Cu) and 22 (Mo). Clearly evident are the reasons for Kiff and Schell's conclusion that the anomalous base metal occurrences are zoned. The higher Cu values are associated with the slate belt rocks and are peripheral to the high Mo values within the granitoids. This zoning could be a feature of a hydrothermal convection system formed by the intrusion of the Sims pluton, or a feature of the original lithologies. The Mo would be a magmatic feature but the elevated Cu concentrations of the slate belt could be an original feature of those rocks. Worthington and Kiff (1970) suggested that low-grade gold ores in the Carolina slate belt were largely conformable and almost entirely within the basal volcanic unit or a short distance stratigraphically above it. This might be true for base metal mineralization as well. The slate belt Cu anomaly outlined by the Lindgren Exploration Company is in a comparable position at the transition between metavolcanic and metasedimentary rocks (Carpenter et al., 1995) (figs. 2a and 21).

Kiff and Schell (unpub. data, 1969) suggested a drilling program as the next exploration step. A drilling program on the right-of-way of the state roads was considered. However, state law required that any record of test drilling be furnished to the State Highway Commission for public record. This was unacceptable. As an alternative, prospecting agreements and options for mineral leases from local landowners were obtained (Claus and Smith, unpub. data, 1970). In 1970 twenty-two, rotary drill holes to depths of 9 to 55 feet were drilled in the northwest and southeast areas. Ninety drill cutting samples from these holes were analyzed for Cu and Mo, and some for W. The results showed that the Cu-Mo anomalies found in the soils (figs. 21 and 22) were associated with bedrock mineralization. This conclusion was sufficient to justify the drilling of fifteen diamond drill holes totaling 3,100 feet into bedrock the following year. Eleven holes were drilled within the greisen in the southeast area and 4 holes were drilled in the northwest to locate the pluton contact (fig. 2b). Holes were started in both the pluton and adjacent wall rocks. There was 2,570 feet of core recovered. The petrography, mineralogy, alteration, and Cu, Mo, Sn, W, and Zn geochemistry of those drillcores were described by Claus and Smith (unpub. data, 1970). Four-inch lengths of the core sampled at 10-foot intervals were split and analyzed for Mo and Cu and for W and Sn at 20-foot intervals. A few Zn analyses were made as well. The average Cu content of the Eastern slate belt drillcore was 69 ppm (30 samples) compared to the average granitoid Cu content of 17 ppm (235 samples). The few Zn analyses also showed higher values for the Eastern slate belt (121 ppm, 2 samples) than for the granitoid (27 ppm, 3 samples). Average granitoid Mo (5.6 ppm, 234 samples), Sn (6.6 ppm, 111 samples), and W (130 ppm, 130 samples) contents were not significantly different from Eastern slate belt rock Mo (5.6 ppm, 30 samples), Sn (5.7 ppm, 14 samples), and W (4.7 ppm, 14 samples). All of these metal concentrations are higher than those reported for this study in table 3. However, the rocks analyzed in table 3 were specifically chosen to be free of any mineralization.

Claus and Smith (unpub. data, 1971) identified three mineralization environments in the drillcores: [1] Quartz-mica greisen containing pyrite, chalcopyrite, and possibly some molybdenite. The greisen was considered a phyllic alteration. [2] Molybdenite- pyrite-, arsenopyrite-, and chalcocite-bearing quartz-calcite veins. These occur as networks of closely spaced cross-cutting and narrow gray to milky quartz veins in granitoids and contorted veins in the Eastern slate belt. The rocks adjacent to the quartz veins are bleached and show argillic alteration. [3] Molybdenite, sphalerite, chalcopyrite, and

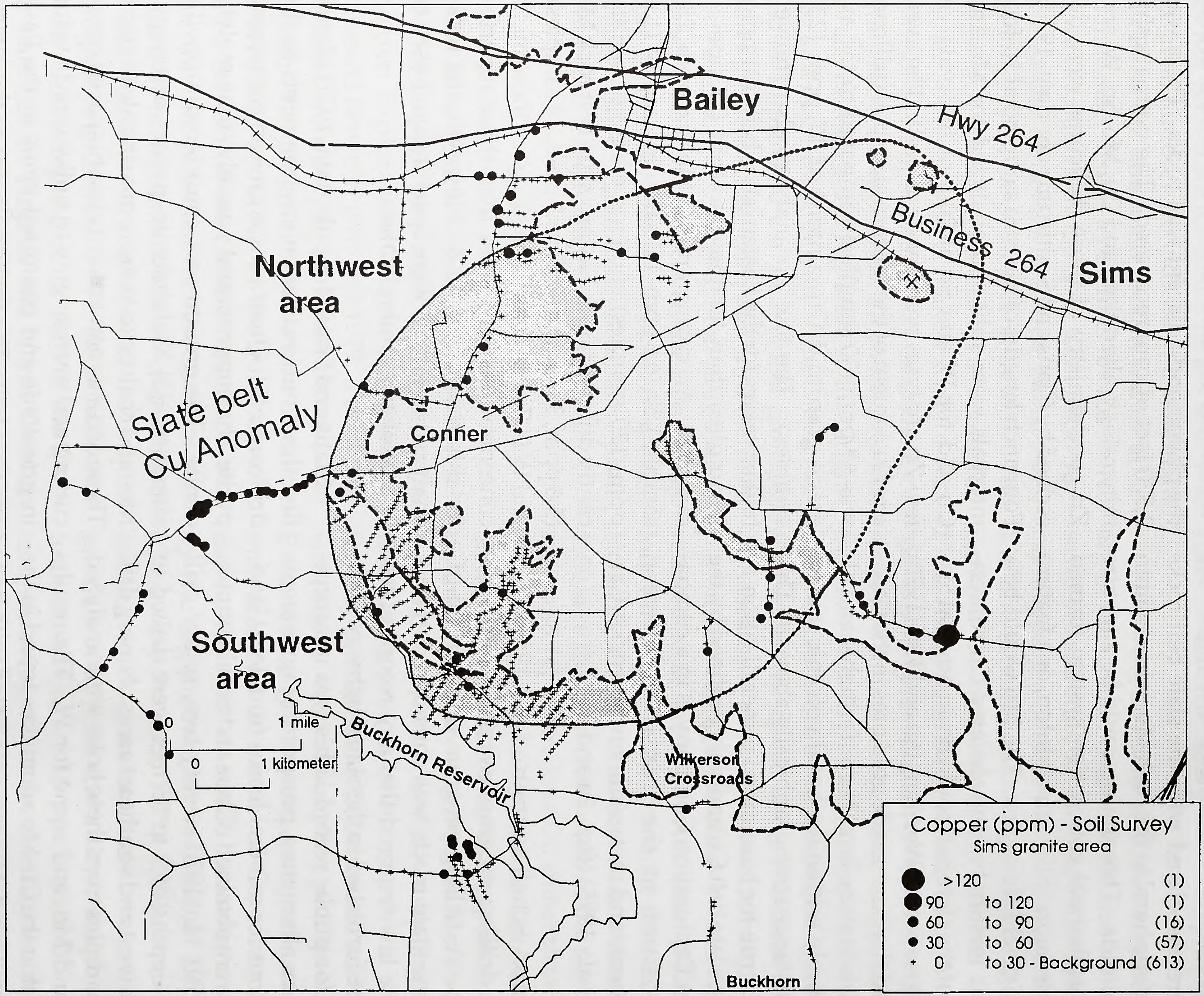


Figure 21. Graphical presentation of the soil copper concentrations in parts per million (ppm) obtained by the Lindgren Exploration Company in the vicinity of the Sims pluton, NC. Data from Kiff and Schell (unpub. data, 1969).

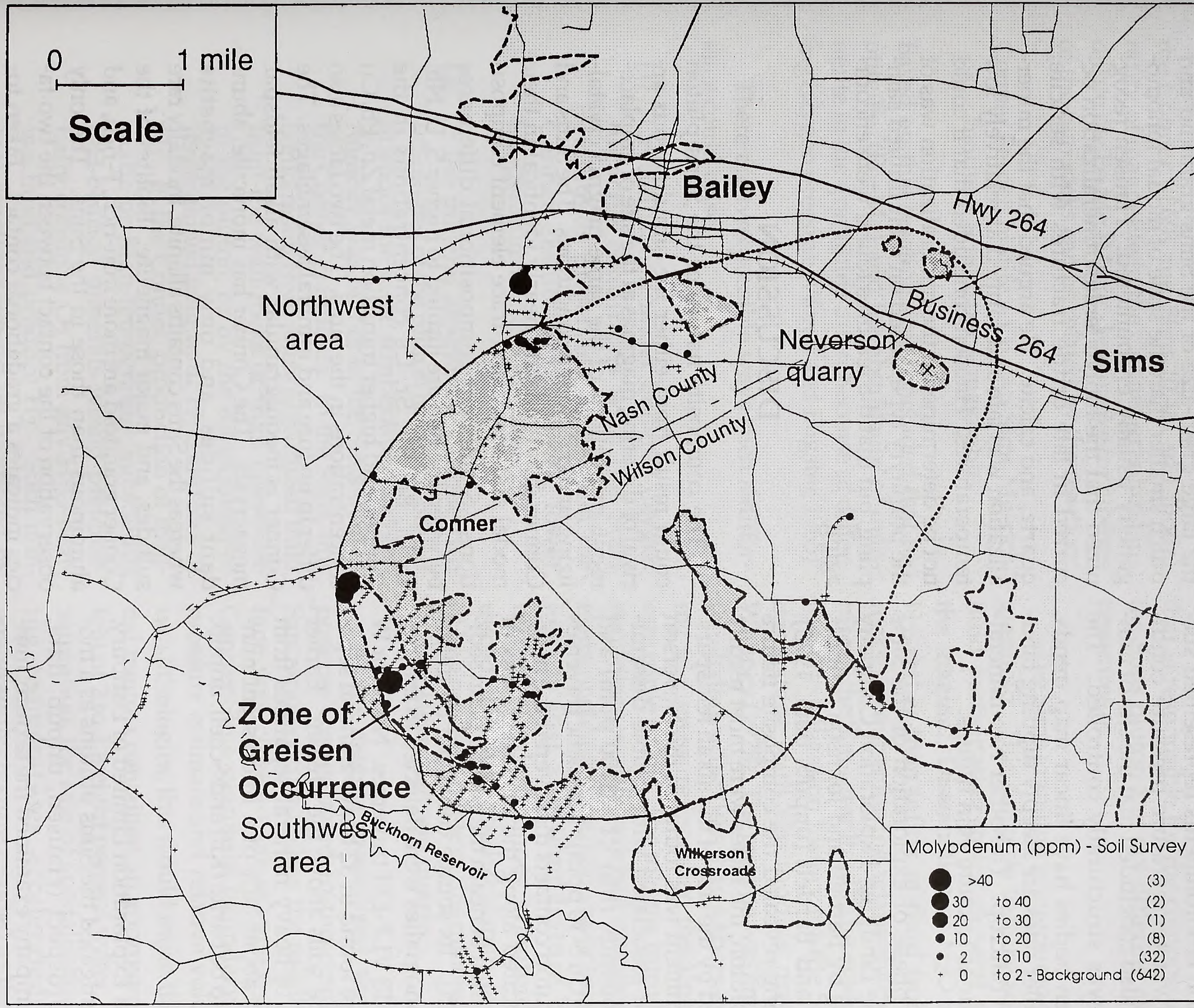


Figure 22. Graphical presentation of the soil molybdenum concentrations in parts per million (ppm) obtained by the Lindgren Exploration Company in the vicinity of the Sims pluton, NC. Data from Kiff and Schell (unpub. data, 1969).

galena in open and vuggy quartz veins both within the pluton and, more commonly, wall rocks near the pluton contact. Claus and Smith (unpub. data, 1971) concluded that the three mineralization environments represented successively lower temperature-pressure conditions. They also concluded that the site of mineralization was structurally controlled. The larger greisen bodies have linear map trends, and the smaller ones are steeply dipping tabular bodies in outcrop. The other two mineralizations occur as fracture vein fillings.

The last phase of exploration of the Sims pluton by the Lindgren Exploration Company was reported by Bartlett and Johnson (unpub. data, 1979), and Bartlett (unpub. data, 1975). Their mapping revealed the composite nature of the Sims pluton; the facies were most readily distinguished by the size of the alkali feldspars. Potash enrichment was found in the Neverson Quarry to be associated with visible disseminated molybdenite (Mo <1 - 3100 ppm) and chalcopyrite (Cu 5-10 ppm). Magnetic traverses across the pluton contacts discovered the magnetic high located along the eastern contact of the pluton buried beneath the coastal plain sediments (fig. 15). Its source could not be determined. No anomalies were detected in the greisen zone by 13 VLF-EM traverses. No Sn or W minerals were found in 32 heavy mineral separates from the soils above the greisen. Earlier examination of heavy mineral separates from soils showed about 30% of a fluorescent mineral thought to be barite (Kiff and Schell, unpub. data, 1969).

Newmont Exploration Limited of Danbury, CT also investigated the Sims plutons as a molybdenum prospect (Hausen, unpub. data, 1979). The company examined the texture, mineralogy, and selected element concentrations of 12 'small' samples collected from the Neverson Quarry. They wanted to determine if the Sims pluton had porphyry Mo mineralization. Sodic plagioclase-rich and alkali feldspar-rich granitoids were distinguished. However, the sample size may have been inappropriate for the large grain-size of the Sims granitoid and much smaller than the scale of modal inhomogeneity usually encountered. Hausen recognized that the molybdenite mineralization occurred in late brittle fractures with sericite, quartz, and calcite. He argued that the mineralization was late and formed at relatively low temperatures. Hausen concluded that it could not be determined if the mineralization was of the porphyry type, based on their limited sampling, but that the features found were encouraging.

DISCUSSION

The composite nature of the Sims pluton could result from either the simultaneous arrival of differing magmas at the site of emplacement, or portions of the same magma crystallizing under different conditions. The Sims and Conner granitoids are nearly identical in their modal and major and trace element compositions. Significant compositional differences between the two are limited to higher S, U, Nb, Ta Li, Be, Rb, Sr, Cs concentrations in the Conner, and higher transition metal Zn, Pb, Cu concentrations in the Sims. The two facies also differ in texture and mineral assemblages. The Conner is inequigranular with alkali feldspar megacrysts. The Conner has monazite, abundant sulfides, and only minor magnetite whereas the Sims contains allanite, modally rare sulfides, and major magnetite. Biotites of the Conner granitoid are more iron-rich, F-rich, and aluminous than those in the Sims. The only observation of the contact between the two facies indicates a gradational contact. Taken together, these characteristics indicate that the composite Sims pluton formed from a single magma batch that crystallized under differing

conditions. This possibility is also allowed for by the close Nd isotopic compositions for the two facies (Samson et al., 1995).

The differing biotite Fe/(Fe+Mg) values of the Conner (0.60) and Sims (0.46) and modal rarity of magnetite in the Conner granitoid indicate the Fe-Mg $[MgFe_{-1}]$ exchange for biotites of the two rocks can be related by the reaction:

Conner Fe-rich biotite + O_2 <=> Sims Mg-rich biotite + K feldspar + magnetite.

Based on this reaction, it is concluded that biotite Fe/(Fe+Mg) and the abundance of magnetite in the granitoids differ because of differing oxygen pressure (Wones and Eugster, 1965).

There are two possible ways such a difference could arise:

[1] Crystallization under buffered oxygen fugacity conditions with the Sims granitoids preserving higher and the Conner granitoids preserving lower temperature mineral assemblages.

[2] If the mineral assemblages in the two lithologies of the pluton last equilibrated at about the same temperature, oxygen fugacity was higher in the Sims than in the Conner granitoids. In the Sims, this could result from entry of oxidized fluid from the wall rocks or from elsewhere in the pluton, or by the dissociation of its contained magmatic H_2O and loss of H_2. In the Conner, production of magmatic or high-temperature subsolidus OH-bearing minerals would preferentially consume O_2 from any H_2O-bearing fluid and produce H_2. Such mineral reactions would be promoted by influx of aqueous fluids, from either the wall rocks or from elsewhere in the pluton.

Thus the difference in mineralogy between the two facies of the Sims pluton resulted from either the differing temperatures of last equilibration or fluid behavior. There are several indications that it is differences in fluid behavior that is responsible for the composite nature of the Sims pluton and not differing closure temperatures.

The Sims granitoid is interior to the Conner granitoid. This suggests that the source of the fluid participating in the mineral reactions is the magma. Dissociation of H_2O and loss of H_2, rather than influx of fluid from the wall rocks, accounts for the relatively oxidized nature of the Sims granitoid. The evidence points to a crystallization history for the Sims pluton consistent with the models presented by Whitney (1975). The magma was emplaced into the shallow crust (less than 4 kbars, corresponding to a pressure less than the aluminum silicate triple point). The magma intruded at these conditions would have had insufficient volatile element content to attain vapor saturation. As heat is lost and temperature drops, the inequigranular Conner granitoid was produced. The large alkali feldspars form because of low nucleation rate of this mineral, compared to the plagioclase and quartz.

As the magma crystallized, the fluid components concentrated in the residual liquid. Saturation occured when the solidifcation surface was close to the mapped gradational Conner-Sims granitoid boundary. From the pressure estimate and relative volumes of the two lithologies, this would mean that the original magma contained an approximate equivalent of 2 to 3 weight percent water. With vapor saturation, the rate of crystallization with falling temperatures accelerated. A more equigranular texture resulted as the nucleation rate of most phases became nearly equal.

The vapor phase concentrated H_2O, Cl, and S from the melt, as well as silica, K, and metals of economic interest, which are then capable of being transported to and deposited in the mineralized areas. The fluid phase separated in equilibrium with the crystalline residue and therefore contained low but significant concentrations of hydrogen and hydrogen sulfide. The oxygen released in this process from the H_2O, OH, and oxidized sulfur complexes in the magma caused the oxygen activity of the residue to rise, stabilizing oxidized phases. The combination of iron extraction and relative oxidation of the iron buffering assembages explains the biotite compositions and modal mineralogy in the Sims granitoid.

The volatile phase transported elements of economic interest to the northwest and southwest contacts of the pluton. In doing so, the fluids passed through the already crystallized Conner granitoid surrounding what would become the Sims granitoid. In most places the fluids reacted with the granitoid to produce magmatic or high-temperature subsolidus OH-bearing alteration mineral assemblages which consumed H_2O from the fluid and the available O_2, resulting in reduced mineral assemblages.

Indications that fluid behavior played a crucial role in the evolution of the Sims pluton also makes more understandable the feature of the Sims pluton that distinguishes it from the other Alleghanian plutons of the southern Appalachians; its mineralization. Segregation and migration of a fluid to the western margins of the pluton was necessary to form the greisen zone by replacement of the Conner granitoid. On the basis of the mineralogy change, this replacement required the addition of Mo, K and H_2O, possibly Si and Al, and loss of Fe, Mg, Ca, Na, and Ti. Subsequent, and lower temperature fluid migration are necessary to form the mineralized fractures widespread through-out the pluton. The occurrence of the mineralizations in linear zones and fractures indicates a structural control. One or more times during these fluid migrations, the redistribution of the trace elements, the S, U, and especially the hydrophile elements Li, Be, Rb, Sr, and Cs to the Conner could have occurred. These elemental differences and the F-rich composition of the greisen muscovite suggests a significant portion the migrating fluid is magmatic in origin. Extensive fluid separation from the magma would also explain the abundance of aplite dikes in the northwest corner of the pluton. This would eventually result in the differing accessory mineralogy of the granitoids in that area and account for the radioactivity and radon anomalies as well.

The Sims pluton was intruded at a depth corresponding to a pressure less than the aluminum silicate triple point. This is about 4 kbars, or depths less than 15 km. This is shallow enough to permit extensive fluid exchange between the country rocks and magma. Did that occur? The Rb-Sr crystallization age of 288 ± 13 Ma and cooling ages of 262 ± 13 Ma indicate cooling of the pluton was rapid, within the time uncertainty of radiometric age determinations. The contact metamorphic effects in the Sims aureole are minor, and confined to a narrow zone. These observations indicate that dehydration of the wall rocks and uptake of the evolved fluid by the magma were minimal, perhaps because of insufficient time.

ACKNOWLEDGMENTS

Field mapping and analytical work on the rocks and minerals were performed as part of a cooperative effort (COGEOMAP, contract Agreements 14-08-0001-A0657 and 14-08-0001-A0742) between the North Carolina Geological Survey and the U. S. Geological Survey. Radon investigations were done under a cooperative

agreement between the U. S. Geological Survey and N. C. State University (Speer, unpub. data, 1992; unpub. data, 1994). Donald W. Lindgren provided both his hospitality and access and permission to use the wealth of information collected by the Lindgren Exploration Company. James Izell arranged access to Nello Teer's Neverson Quarry. Robert H. Carpenter produced the computer-drawn maps, work that is much appreciated. The manuscript benefited from reviews by James A. Whitney, P. Albert Carpenter, III, Robert H. Carpenter, Harry Y. McSween, and Jeffrey C. Reid.

REFERENCES CITED

Barwick, M., Gray, B. E., Gray, B. W., Isnard, A., and Sutton, M., 1978, A mineralogical study of the Neverson Quarry, Wilson County, North Carolina: Journal of the Elisha Mitchell Scientific Society, v. 94, p. 73.

Carpenter, R. H., and Carpenter, S. F., 1991, Heavy mineral deposits in the upper Coastal Plain of North Carolina and Virginia: Economic Geology, v. 86, p. 1657-1671.

Carpenter, R. H., Tanner, J. T., Jr., Grotto, D. J., Carpenter, P. A., III, and Speer, J. A., 1995, Investigation of muscovite mica in greisen, Sims granitoid intrusive, Wilson County, North Carolina: North Carolina Geological Survey Informational Circular 30, 14 p.

Carpenter, P. A., III, Carpenter, R. H., Speer, J. A., and Stoddard, E. F., 1995, Geology of the Stancils Chapel 7.5-minute quadrangle, Johnston, Nash, and Wilson Counties, North Carolina: North Carolina Geological Survey Open-File Report 94-3, 15 p., and 3 maps, scale 1:24,000.

Cook, R. B., 1972, Exploration for disseminated molybdenum-copper mineralization in the Conner Stock, Wilson and Nash Counties, North Carolina: Economic Geology v. 67, p. 1003-1004.

Councill, R. J., 1954, The commercial granitoids of North Carolina: North Carolina Division of Mineral Resources Bulletin 67, p. 10-11.

Farrar, S. S., 1985, Stratigraphy of the northeastern North Carolina Piedmont: Southeastern Geology, v. 25, p. 159-183.

Geological Society of America, 1979, Rock-color chart, The Rock-Color Chart Committee: Geological Society of America, Boulder, CO.

Haworth, R. T., Daniels, D. L., Williams, H., and Zietz, I., 1980, Bouguer gravity anomaly map of the Appalachian Orogen: Memorial University of Newfoundland Map 3a, scale 1:2,000,000.

Hoffman, C. W., and Carpenter, R. H., 1992, Heavy-mineral deposits in the Bailey area, Nash and Wilson Counties, North Carolina, *in* Dennison, J. M., and Stewart, K. G., editors, Geologic field guides to North Carolina and vicinity: Geological Society of America, Southeastern Section, Geologic Guidebook No. 1, p. 49-63.

Horton, J. W., Jr., Drake, A. A., Jr., and Rankin, D. W., 1989, Tectonostratigraphic terranes and their Paleozoic boundaries in the central and southern Appalachians: Geological .Society of America Special Paper 230, p. 213-245.

Irvine, T. N., and Baragar, W. R, A., 1971, A guide to the chemical classification of the common volcanic rocks: Canadian Journal of Earth Sciences, v. 8, p. 523-548.

Lawrence, D.P., 1996, Simple bouguer gravity

anomaly map, Raleigh 30 X 60-minute quadrangle: North Carolina Geological Survey Geologic Map Series 4.

LeMaitre, R. W., 1989, A classification of igneous rocks and glossary of terms: recommendations of the International Union of Geological Sciences Subcommission on the Systematics of Igneous Rocks: Blackwell Scientific Publications, 193 p.

Nakamura, N., 1983, Determination of REE, Ba, Mg, Na, and K in carbonaceous and ordinary chondrites: Geochemica et Cosmochimica Acta, v. 38, p. 757-775.

North Carolina Department of Transportation, 1990, Quality of coarse aggregate from approved sources as of February 15, 1990: Report No. 110, 5 p.

N. C. Geological Survey, 1985, Geologic map of North Carolina: North Carolina Department of Natural Resources and Community Development, scale 1:500,000.

Reimer, G. M., 1991, Simple techniques for soil-gas and water sampling for radon analysis: U. S. Geological Survey Bulletin 1971, p. 19-22.

Samson, S. D., Coler, D. C., and Speer, J. A., 1995, Geochemical and Nd-Sr-Pb isotopic composition of Alleghanian granites of the southern Appalachians: Origin, tectonic setting, and source characterization: Earth and Planetary Science Letters v. 134, p. 359-376.

Sando, T. W., 1979, Trace elements in Hercynian granitic rocks of the southeastern Piedmont, U.S.A.: Chapel Hill, University of North Carolina, M.S. Thesis, 91 p.

Spanjers, R. P., 1983, Lineament and fracture analysis of three molybdenite-bearing granitic plutons in the eastern Piedmont of North Carolina: Raleigh, North Carolina State University, M. S. Thesis, 41 p.

Speer, J. A., 1981, The nature and magnetic expression of isograds in the contact aureole of the Liberty Hill pluton, South Carolina: Summary and Part II: Geological Society of America Bulletin, v. 92, p. 603-609 and p. 1262-1358.

Speer, J. A., Becker, S. W., and Farrar, S.S., 1980, Field relations and petrology of the postmetamorphic, coarse - grained granitoids and associated rocks in the southern Appalachian Piedmont, *in* Wones, D. R., editors, *The Caledonides in the USA*, Department of Geological Sciences, VPI&SU Memoir No. 2., p. 137-148.

Speer, J. A., Bertwell, G. T., Hoff, K. W., and Douglas, T. J., 1993. Using heat flow measurements to estimate and verify the total radon hazard potential of granites, southeastern United States. 1993 International Radon Conference Preprints, "Communicating the Radon Conference," American Association of Radon Scientists and Technologists, IV 10- IV 19.

Speer, J.A., and Hoff, K., in press, Elemental composition of the Alleghanian granitoid plutons of the southern Appalachians, United States, *in* Sinha, A.K., (ed.), The nature of magmatism in the Appalachian Orogen: Geological Society of America, Boulder, Co.

Taylor, S.R., and McLennan, S.M., 1985, The Continental Crust: its composition and evolution: Blackwell Scientific Publications, Oxford, 312 p.

U. S. Geological Survey, 1975, Aeroradioactivity maps of parts of Georgia, South Carolina, and North Carolina, Total Count Gamma Ray Intensity: U. S. Geological Survey Open-File Report 75-400, Sheet 13 of 15, scale 1:250,000.

U.S. Geological Survey, 1976, Aeromagnetic maps of parts of Georgia, South Carolina, and North Carolina, Residual Magnetic Intensity: U. S. Geological Survey Open File Report 76-181, Sheet 2 of 13, scale 1:250,000.

Wagener, H. D., 1977, The granitic stone resources of South Carolina: South Carolina Geological Survey Mineral Resources Series 5, text 65 p., 24 maps, map scale 1:125,000.

Wedemeyer, R. C., 1981, Geochemistry and geochronology of the Sims granitoid, Eastern Carolina slate belt, North Carolina: Greenville, Eastern Carolina University, M.S. Thesis, 63 p.

Whitney, J. A., 1975, The effects of pressure, temperature, and $X(H_2O)$ on phase assemblage in four synthetic rock compositions: Journal of Geology, v. 83, p. 1-31.

Wilson, W. F., 1979, Geology of Wilson County, N.C.: North Carolina Geological Survey Open-File Report 79-2, 1 sheet, scale 1:125,000.

Wilson, W.F., and Spence, W.H., 1979, Geologic map of Nash County, North Carolina: North Carolina Geological Survey, Open-File Report 79-3, 1 sheet, scale 1:125,000.

Table 1. Modal Analysis, Sims pluton,
Nash and Wilson Counties, North Carolina

	Conner granitoid			*Sims granitoid*		
	SI-3	SI-4	SI-11	SI-14	SI-26	SI-27
quartz	29.4	-	-	23.4	29.7	27.6
alkali feldspar	38.2	-	-	36.3	34.3	29.2
plagioclase	28.3	-	-	38.5	34.6	39.4
color index	4.1	-	-	1.6	1.2	3.5
grid size, mm	5	-	-	5	5	5
number of points	1800	-	-	1113	1234	1171
specific gravity	2.65±.01	2.65±.01	2.65±.01	2.65±.01	2.64±.01	2.65±.01

Table 2. Rock Major Element Analyses, Sims pluton, Nash and Wilson counties, North Carolina

	Conner granitoid			*Sims granitoid*			*Alleghanian granitoids*	
	SI-3	SI-4	SI-11	SI-14	SI-26	SI-27	mean	std. dev.
SiO_2	74.97	74.12	74.5	73.95	73.86	73.56	71.26	3.49
TiO_2	0.26	0.26	0.26	0.30	0.29	0.29	0.36	0.22
Al_2O_3	13.85	13.57	13.74	14.27	13.82	14.28	14.81	1.14
Fe2O3	0.58	1.12	0.27	1.15	1.11	1.59	1.02	0.41
FeO	0.99	0.49	0.71	0.80	0.75	0.34	1.12	0.75
MnO	0.05	0.01	0.06	0.05	0.05	0.05	0.06	0.05
MgO	0.48	0.43	0.42	0.51	0.50	0.50	0.63	0.44
CaO	1.33	1.16	1.21	1.57	1.44	1.53	1.66	0.80
Na_2O	3.79	3.77	3.91	3.86	3.74	3.96	3.78	0.56
K_2O	4.49	4.85	4.67	4.53	4.73	4.69	4.70	0.86
H_2O+	0.45	0.53	0.40	0.47	0.62	0.59	0.32	0.24
H_2O-	0.13	0.16	0.09	0.08	0.11	0.11	0.10	0.05
P_2O_5	0.19	0.16	0.17	0.19	0.17	0.18	0.13	0.09
BaO	0.05	0.05	0.05	0.08	0.07	0.07	0.08	0.04
CO_2	< 0.2	0.3	< 0.2	< 0.2	< 0.2	0.3	0.30	0.15
F	0.09	0.09	0.09	0.08	0.09	0.09		
Cl	0.02	0.01	0	0.01	0	0.02		
S	0.04	0.07	0.02	0	0	0	0.028	0.028
O = F,Cl,S	-0.06	-0.08	-0.05	-0.04	-0.04	-0.04		
TOTAL	101.75	101.15	100.57	101.9	101.34	102.15		
		petrochemical parameters						
$Fe^{+2}/(Fe^{+2}+Fe^{+3})$	0.791	0.494	0.853	0.607	0.601	0.322		
Fe/(Fe+Mg)	0.594	0.564	0.527	0.592	0.583	0.542		
A/CNK	1.025	1.001	1.004	1.012	0.995	0.994		
		CIPW norms						
quartz	32.58	32.02	31.01	30.7	30.8	30.16		
orthoclase	26.66	28.78	27.72	26.97	28.12	27.89		
albite	31.92	31.83	33.09	32.59	31.65	33.36		
anorthite	4.82	2.26	4.34	6.09	5.49	3.98		
corundum	0.98	1.27	0.63	0.75	0.49	1.21		
hypersthene	2.12	1.07	1.77	1.39	1.32	1.25		
magnetite	0.84	0.61	0.39	1.67	1.61	0.42		
ilmenite	0.49	0.49	0.49	0.57	0.55	0.55		
hematite		0.70				1.30		
apatite	0.45	0.38	0.40	0.45	0.40	0.43		
halite	0.03	0.02		0.02		0.03		
fluorite	0.15	0.16	0.15	0.13	0.15	0.15		
pyrite	0.07	0.13	0.04					
TOTAL	101.13	99.72	100.04	101.31	100.58	100.73		

Table 3. Rock Trace Element Analyses, Sims pluton, Nash and Wilson Counties, North Carolina

	Conner granitoid			*Sims granitoid*			*Alleghanian granitoids*	
	SI-3	SI-4	SI-11	SI-14	SI-26	SI-27	mean	std. dev.
Li, ppm	33	36	35	27	26	29	30	17
Be	3.7	4	4.2	2.8	3.3	3.3	3.2	1.8
B	5	5	<5	<5	5	5	10.8	5.8
F	860	940	860	820	880	910	915	614
Cl	200	100	<100	100	<100	200	157.1	78.7
Sc	5.5	5.5	5.5	4.5	5.5	5.5	4.7	2.1
V	30	32	28	33	33	31	27.9	17.5
Cr	14	17	20	16	15	16	12.5	9.4
Co	1	<1	1	1	<1	1	7	5.1
Ni	1	2	1	1	2	2	5.5	4.5
Cu	8	11	7	5	4	4	20.5	16.1
Zn	40	38	38	48	47	54	52.3	16.9
Ga	14	14	16	14	14	14	15.2	4.7
Ge	<5	<5	<5	<5	<5	<5	10	10
Rb	214	220	200	170	161	165	188.5	66.8
Sr	89	98	89	122	106	109	237.5	226.5
Y	20	15	20	15	20	20	33.1	27.6
Nb	40	40	45	20	30	25	22.4	12.8
Mo	<1	1	<1	<1	<1	<1	2.6	3.6
Cd	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.15	0.1
Sn	<2	<2	<2	<2	<2	<2	1.1	0.4
Cs	7	6.5	3.5	1	2	3.5	2.7	1.7
La	42	44	45	46	44	47	72.2	33.1
Ce	100	90	92	94	88	94	125.9	71.8
Pr	10	10	10	10	10	10	10	
Nd	15	20	25	30	30	35	42.4	28.5
Sm	4.8	4.7	4.9	4.6	5.4	5.1	7.4	3.8
Eu	<0.5	0.5	<0.5	1	0.5	<0.5	1.3	0.8
Gd	<50	<50	<50	<50	<50	<50	6.1	4
Tb	0.3	0.4	0.6	0.3	<0.1	<0.1	0.9	0.5
Dy	2	3	2	1	2	2	4.7	2.4
Ho	<1	<1	<1	<1	<1	<1		
Er	<20	<20	<20	<20	<20	<20	2	1.4
Tm	<1	1	<1	<1	1	<1	1	
Yb	2.1	1.9	1.3	2	2	1.8	2.3	1.2
Lu	0.3	0.2	0.3	0.3	0.3	0.3	0.4	0.2
Hf	10	12	12	14	12	14	10.9	4.7
Ta	4	2	4	<2	<2	<2	5.1	4.9
W	<2	<2	<2	<2	<2	<2	1	
Pb	7	7	7	8	10	10	33.3	25.6
Th	26	22	25	25	24	29	24.7	12.2
U	11	11	12	6	5	6	5.6	4.8

Table 4. Biotite Analyses, Sims Pluton, Nash and Wilson Counties, North Carolina

	Conner granitoid												*Sims granitoid*							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
SiO_2	36.7	35.2	35.1	35.7	36.0	36.5	35.2	35.1	35.6	34.5	37.1	37.1	37.1	37.8	38.7	37.9	36.9	37.4	38.5	37.7
TiO_2	2.46	2.27	2.68	2.59	2.83	3.23	3.01	2.53	2.65	2.39	2.38	2.64	2.63	2.95	2.50	2.67	3.15	3.32	3.13	2.77
Al_2O_3	16.3	17.1	17.0	16.1	16.8	16.6	16.7	16.7	16.5	16.4	16.5	16.5	14.9	14.0	14.2	15.5	14.9	14.9	14.8	15.2
FeO	18.6	22.3	21.4	23.1	22.2	21.7	21.9	21.8	21.8	19.9	18.7	18.0	16.9	17.3	16.0	16.6	17.7	17.0	17.0	17.6
MnO	0.74	0.76	0.75	0.50	0.74	0.81	0.77	0.61	0.85	0.59	0.74	0.52	0.53	0.61	0.43	0.53	0.59	0.55	0.57	0.52
MgO	8.82	7.36	7.61	7.72	7.23	7.34	7.55	8.07	7.97	9.61	9.28	9.34	11.5	11.5	12.3	11.4	10.8	10.5	11.1	10.8
CaO	0.04	0.01	0.01	0.01	0.02	0.03	0.01	0.00	0.02	0.01	0.02	0.02	0.03	0.03	0.01	0.01	0.02	0.01	0.00	0.04
Na_2O	0.07	0.04	0.04	0.08	0.05	0.08	0.11	0.06	0.07	0.07	0.08	0.06	0.06	0.06	0.10	0.05	0.14	0.06	0.09	0.14
K_2O	9.55	9.60	9.60	9.63	9.47	9.73	9.66	9.74	9.57	9.83	9.86	9.82	9.72	9.62	9.39	9.84	9.57	9.68	9.66	9.52
F	0.73	0.66	0.74	0.82	0.66	0.71	0.72	0.67	0.81	0.89	1.09	0.82	0.94	1.69	1.31	0.99	1.00	0.86	0.88	1.21
Cl	0.04	0.04	0.05	0.05	0.08	0.09	0.07	0.07	0.09	0.05	0.05	0.03	0.05	0.04	0.02	0.03	0.05	0.04	0.09	0.07
H_2O	3.50	3.50	3.46	3.45	3.53	3.54	3.48	3.49	3.45	3.36	3.38	3.51	3.42	3.10	3.31	3.48	3.39	3.47	3.51	3.34
Sum	97.55	98.84	98.44	99.75	99.61	####	99.18	98.84	99.38	97.60	99.18	98.36	97.78	98.70	98.27	99.00	98.21	97.79	99.33	98.91
O=F+Cl	0.32	0.29	0.32	0.36	0.30	0.32	0.32	0.30	0.36	0.39	0.47	0.35	0.41	0.72	0.56	0.42	0.43	0.37	0.39	0.53
Total	97.23	98.55	98.12	99.39	99.31	####	98.86	98.54	99.02	97.21	98.71	98.01	97.37	97.98	97.71	98.58	97.78	97.42	98.94	98.38
	number of cations on the basis of 24 (O, OH, F, Cl)																			
Si	5.702	5.519	5.501	5.558	5.579	5.611	5.492	5.498	5.535	5.445	5.686	5.703	5.734	5.813	5.899	5.759	5.699	5.763	5.824	5.757
Al^{iv}	2.298	2.481	2.499	2.442	2.421	2.389	2.508	2.502	2.465	2.555	2.314	2.297	2.266	2.187	2.101	2.241	2.301	2.237	2.176	2.243
sum	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000
Al^{vi}	0.697	0.670	0.641	0.518	0.645	0.607	0.567	0.568	0.569	0.495	0.675	0.693	0.437	0.340	0.449	0.536	0.409	0.469	0.471	0.498
Ti	0.288	0.268	0.316	0.304	0.330	0.374	0.354	0.298	0.311	0.283	0.275	0.305	0.306	0.341	0.286	0.305	0.366	0.385	0.357	0.318
Fe	2.417	2.915	2.807	3.006	2.869	2.781	2.853	2.855	2.831	2.621	2.393	2.316	2.180	2.221	2.034	2.105	2.280	2.188	2.148	2.243
Mn	0.097	0.100	0.100	0.066	0.096	0.105	0.102	0.081	0.112	0.078	0.096	0.068	0.069	0.080	0.056	0.069	0.077	0.073	0.074	0.067
Mg	2.046	1.718	1.779	1.791	1.670	1.679	1.757	1.882	1.848	2.263	2.123	2.138	2.643	2.636	2.783	2.568	2.477	2.418	2.498	2.465
sum	5.545	5.671	5.643	5.685	5.610	5.546	5.633	5.684	5.671	5.740	5.562	5.520	5.635	5.618	5.608	5.583	5.609	5.533	5.548	5.591
Ca	0.006	0.003	0.002	0.002	0.003	0.050	0.002	0.000	0.003	0.002	0.003	0.004	0.005	0.004	0.001	0.002	0.003	0.002	0.001	0.007
Na	0.022	0.011	0.012	0.025	0.014	0.024	0.034	0.018	0.021	0.021	0.024	0.018	0.019	0.019	0.031	0.015	0.043	0.019	0.025	0.041
K	1.895	1.918	1.921	1.912	1.872	1.907	1.923	1.945	1.900	1.980	1.930	1.924	1.913	1.887	1.825	1.904	1.886	1.906	1.866	1.856
sum	1.923	1.932	1.935	1.939	1.889	1.981	1.959	1.963	1.924	2.003	1.957	1.946	1.937	1.910	1.857	1.921	1.932	1.927	1.892	1.904
Cl	0.011	0.011	0.012	0.013	0.020	0.022	0.019	0.019	0.024	0.013	0.012	0.009	0.013	0.010	0.005	0.008	0.013	0.009	0.022	0.018
F	0.361	0.327	0.367	0.402	0.326	0.347	0.357	0.334	0.399	0.445	0.529	0.397	0.459	0.822	0.631	0.473	0.491	0.417	0.424	0.585
OH	3.629	3.659	3.619	3.585	3.654	3.627	3.625	3.649	3.578	3.543	3.460	3.597	3.528	3.180	3.367	3.524	3.497	3.576	3.552	3.406
sum	4.001	3.997	3.998	4.000	4.000	3.996	4.001	4.002	4.001	4.001	4.001	4.003	4.000	4.012	4.003	4.005	4.001	4.002	3.998	4.009
F/(FM)	0.54	0.63	0.61	0.63	0.63	0.62	0.62	0.60	0.61	0.54	0.53	0.52	0.45	0.46	0.42	0.45	0.48	0.48	0.46	0.48

1 SF8-318, matrix biotite
2 SI-2a, matrix biotite
3 SI-2a, inclusion in quartz
4 SI-2b, matrix biotite
5 SI-3, matrix biotite
6 SI-3a, matrix biotite
7 SI-3b, matrix biotite
8 SI-3b, enclave matrix biotite
9 SI-4, matrix biotite
10 SI-7, matrix biotite
11 SI-11, matrix biotite
12 SI-21a, matrix biotite
13 F7-163, matrix biotite
14 SI-14, inclusion in quartz
15 SI-14, matrix biotite
16 SI-26, biotite core of muscovite
17 SI-26, matrix biotite w/ chl?
18 SI-26, inclusion in quartz
19 SI-27, matrix biotite
20 SI-27a, enclave biotite

Table 5. Muscovite Analyses, Sims Pluton, Nash and Wilson Counties, North Carolina

	Conner granitoid														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
SiO_2	46.3	44.5	48.7	45.5	45.0	47.1	47.1	46.3	44.7	46.1	44.6	45.0	47.5	46.9	46.1
TiO_2	0.98	1.42	0.42	0.09	0.61	0.11	0.04	0.08	0.76	0.05	0.63	0.85	1.12	2.39	1.01
Al_2O_3	28.2	30.6	25.8	34.1	28.5	28.9	35.8	38.6	29.8	36.4	29.9	27.7	27.7	25.8	29.5
FeO	4.64	3.67	4.95	1.70	5.82	3.73	0.40	0.51	4.86	0.51	4.90	4.96	5.37	5.08	4.70
MnO	0.11	0.12	0.11	0.06	0.09	0.00	0.07	0.02	0.10	0.08	0.06	0.07	0.11	0.04	0.01
MgO	1.86	1.52	2.46	0.53	2.25	2.57	0.08	0.10	1.51	0.05	1.43	2.59	2.27	2.39	1.42
CaO	0.01	0.01	0.22	0.02	0.01	0.02	0.11	0.11	0.01	0.02	0.01	0.01	0.00	0.00	0.01
Na_2O	0.18	0.40	1.95	0.42	0.23	0.18	0.75	1.23	0.31	0.39	0.42	0.23	0.17	0.15	0.26
K_2O	10.7	10.7	8.74	10.8	10.9	10.8	10.4	9.50	10.7	10.3	10.6	10.6	11.2	10.7	10.9
F	0.38	0.31	0.37	0.12	0.42	0.29	0.07	0.08	0.27	0.07	0.33	0.41	0.48	0.33	0.19
Cl	0.02	0.01	0.01	0.00	0.02	0.02	0.02	0.03	0.01	0.00	0.02	0.01	0.02	0.01	0.01
H_2O	4.11	4.15	4.16	4.33	4.06	4.20	4.47	4.55	4.14	4.44	4.10	4.04	4.15	4.14	4.24
Sum	97.49	97.41	97.89	97.67	97.91	97.92	99.31	101.11	97.17	98.41	97.00	96.47	100.09	97.93	98.35
O=F+Cl	0.16	0.13	0.16	0.05	0.18	0.13	0.03	0.04	0.12	0.03	0.14	0.17	0.21	0.14	0.08
Total	97.33	97.28	97.73	97.62	97.73	97.79	99.28	101.07	97.05	98.38	96.86	96.30	99.88	97.79	98.27
	number of cations on the basis of 24 (O, OH, F, Cl)														
Si	6.456	6.201	6.728	6.220	6.321	6.500	6.262	6.028	6.275	6.180	6.267	6.372	6.497	6.537	6.369
Al^{iv}	1.544	1.799	1.272	1.780	1.679	1.500	1.738	1.972	1.725	1.820	1.733	1.628	1.503	1.463	1.631
sum	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000
Al^{vi}	3.097	3.224	2.927	3.711	3.026	3.194	3.867	3.954	3.200	3.923	3.227	3.000	2.955	2.777	3.176
Ti	0.103	0.149	0.044	0.009	0.064	0.011	0.004	0.008	0.080	0.005	0.067	0.090	0.115	0.250	0.105
Fe	0.542	0.429	0.572	0.194	0.684	0.430	0.044	0.056	0.571	0.057	0.576	0.587	0.614	0.592	0.544
Mn	0.013	0.014	0.013	0.007	0.011	0.000	0.008	0.002	0.012	0.009	0.008	0.008	0.013	0.005	0.001
Mg	0.387	0.315	0.507	0.108	0.471	0.528	0.016	0.019	0.316	0.010	0.301	0.546	0.463	0.496	0.294
sum	4.142	4.131	4.063	4.029	4.256	4.163	3.939	4.039	4.179	4.004	4.179	4.231	4.160	4.120	4.120
Ca	0.001	0.001	0.033	0.003	0.002	0.003	0.016	0.015	0.002	0.003	0.002	0.002	0.000	0.000	0.002
Na	0.049	0.107	0.523	0.111	0.063	0.048	0.193	0.311	0.086	0.101	0.115	0.063	0.046	0.040	0.071
K	1.901	1.901	1.541	1.873	1.946	1.900	1.755	1.579	1.914	1.764	1.893	1.915	1.950	1.906	1.927
sum	1.951	2.009	2.097	1.987	2.011	1.951	1.964	1.905	2.002	1.868	2.010	1.980	1.996	1.946	2.000
Cl	0.005	0.002	0.002	0.000	0.006	0.005	0.005	0.007	0.002	0.000	0.005	0.002	0.005	0.002	0.004
F	0.168	0.135	0.162	0.052	0.186	0.127	0.029	0.033	0.122	0.030	0.147	0.182	0.206	0.145	0.083
OH	3.826	3.862	3.835	3.945	3.805	3.865	3.965	3.956	3.874	3.969	3.846	3.814	3.785	3.846	3.910
sum	3.999	3.999	3.999	3.997	3.997	3.997	3.999	3.996	3.998	3.999	3.998	3.998	3.996	3.993	3.997
F/(FM)	0.58	0.58	0.53	0.64	0.59	0.45	0.73	0.75	0.64	0.85	0.66	0.52	0.57	0.54	0.65

1 SF8-318
2 SI-2a, matrix muscovite w/ biotite
3 Si-2a, musc in plag
4 SI-2a, musc in plag
5 SI-3, matrix musc w/ biot
6 SI-3, musc w/ chl.
7 SI-3, musc in plag
8 SI-3a, musc w/ plag
9 SI-3b, enclave, matrix musc w/ bt
10 SI-3b, musc in plag
11 SI-4
12 SI-7
13 SI-11
14 SI-14, matrix ms w/ bt
15 SI-21a, matrix ms w/ bt

Table 5 (cont.). Muscovite Analyses, Sims Pluton, Nash and Wilson Counties, North Carol

	Sims granitoid								*aplite*	*greisen*		
	16	17	18	19	20	21	22	23	24	25	26	27
SiO_2	47.4	47.1	47.0	46.2	47.8	46.3	47.0	46.2	48.2	45.9	46.6	46.1
TiO_2	0.37	1.88	0.18	0.17	0.19	0.61	0.57	0.04	0.25	0.75	0.06	0.75
Al_2O_3	26.2	26.7	27.1	28.9	27.7	26.9	28.8	35.7	28.2	31.6	32.4	31.3
FeO	5.14	5.00	5.14	3.85	4.86	4.90	4.77	1.58	4.25	3.54	2.90	3.51
MnO	0.06	0.07	0.13	0.09	0.05	0.12	0.08	0.00	0.11	0.01	0.01	0.03
MgO	2.70	2.33	2.55	1.57	2.62	2.63	2.12	0.39	2.41	1.15	0.99	1.13
CaO	0.03	0.00	0.04	0.02	0.01	0.04	0.01	0.00	0.01	0.10	0.04	0.02
Na_2O	0.14	0.13	0.16	0.24	0.16	0.23	0.27	0.93	0.12	0.55	0.59	0.49
K_2O	10.9	10.7	10.4	10.3	11.1	11.0	10.9	10.3	11.3	9.88	10.4	10.4
F	0.34	0.31	0.42	0.12	0.36	0.21	0.30	0.13	0.39	0.24	0.33	0.34
Cl	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.00	0.00	0.00	0.01
H_2O	4.12	4.18	4.09	4.20	4.19	4.16	4.22	4.43	4.20	4.25	4.24	4.21
Sum	97.41	98.40	97.21	95.66	99.04	97.10	99.05	99.72	99.44	97.97	98.56	98.29
O=F+Cl	0.14	0.13	0.18	0.05	0.15	0.09	0.13	0.06	0.16	0.10	0.14	0.14
Total	97.27	98.27	97.03	95.61	98.89	97.01	98.92	99.66	99.28	97.87	98.42	98.15
Si	6.634	6.524	6.578	6.506	6.568	6.505	6.451	6.167	6.574	6.297	6.337	6.326
Al^{iv}	1.366	1.476	1.422	1.494	1.432	1.495	1.549	1.833	1.426	1.703	1.663	1.674
sum	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000
Al^{vi}	2.955	2.874	3.048	3.303	3.050	2.970	3.112	3.772	3.112	3.401	3.531	3.379
Ti	0.039	0.195	0.019	0.018	0.019	0.065	0.059	0.004	0.026	0.077	0.007	0.078
Fe	0.602	0.579	0.602	0.453	0.558	0.576	0.548	0.176	0.485	0.406	0.330	0.403
Mn	0.007	0.008	0.015	0.011	0.005	0.014	0.009	0.000	0.013	0.001	0.001	0.004
Mg	0.564	0.481	0.530	0.329	0.537	0.551	0.434	0.078	0.490	0.235	0.201	0.231
sum	4.167	4.137	4.214	4.114	4.169	4.176	4.162	4.030	4.126	4.120	4.070	4.095
Ca	0.004	0.001	0.006	0.003	0.001	0.006	0.002	0.000	0.001	0.015	0.005	0.003
Na	0.037	0.035	0.042	0.066	0.043	0.063	0.072	0.240	0.032	0.146	0.156	0.131
K	1.951	1.898	1.848	1.850	1.953	1.966	1.912	1.745	1.975	1.729	1.807	1.812
sum	1.992	1.934	1.896	1.919	1.997	2.035	1.986	1.985	2.008	1.890	1.968	1.946
Cl	0.002	0.001	0.001	0.000	0.001	0.000	0.002	0.005	0.000	0.000	0.001	0.002
F	0.149	0.138	0.186	0.053	0.154	0.093	0.130	0.055	0.168	0.104	0.142	0.147
OH	3.846	3.857	3.811	3.944	3.844	3.903	3.867	3.941	3.825	3.891	3.855	3.848
sum	3.997	3.996	3.998	3.997	3.999	3.996	3.999	4.001	3.993	3.995	3.998	3.997
F/(FM)	0.52	0.55	0.53	0.58	0.51	0.51	0.56	0.69	0.50	0.63	0.62	0.64

16 F7-163, matrix muscovite w/ biot
17 SI-14, matrix biotite
18 SI-14, overgrowth on biotite
19 SI-14, musc in plag
20 SI-26, musc overgrown on biotite
21 SI-27, musc in plag.
22 SI-27a, enclave, matrix musc w/ biot
23 SI-27a, musc w/ plag + cal
24 SI-27b, matrix musc
25 SF7-318.2
26 SF8-319, light muscovite zone
27 SF8-319, dark muscovite zone

Table 6. Feldspar Analyses, Sims Pluton, Nash and Wilson Counties, North Carolina

	Conner granitoid													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
SiO_2	65.2	65.5	63.5	63.3	63.6	62.0	62.3	64.7	66.5	66.3	62.1	62.7	60.6	62.8
TiO_2	0.01	0.04	0.00	0.03	0.01	0.02	0.00	0.01	0.00	0.00	0.01	0.02	0.00	0.00
Al_2O_3	21.5	21.2	21.4	21.6	18.3	18.1	22.1	22.0	21.1	21.0	18.3	21.5	22.2	21.1
FeO	0.00	0.05	0.05	0.09	0.00	0.14	0.01	0.04	0.06	0.06	0.09	0.07	0.20	0.00
MnO	0.00	0.03	0.00	0.01	0.00	0.07	0.04	0.00	0.00	0.01	0.00	0.02	0.00	0.02
MgO	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.01	0.01	0.02	0.00	0.00	0.01
CaO	2.56	2.35	2.41	2.59	0.02	0.01	3.53	2.79	1.13	2.11	0.03	2.50	3.42	2.24
Na_2O	10.1	10.1	9.91	9.98	0.29	0.56	9.56	10.5	11.4	10.4	0.43	10.2	9.67	10.3
K_2O	0.32	0.61	0.56	0.34	16.5	15.8	0.19	0.21	0.08	0.16	16.2	0.15	0.30	0.46
Total	99.71	99.88	97.81	97.94	98.74	96.69	97.74	100.20	100.25	100.02	97.14	97.11	96.37	96.84
	number of cations on the basis of 8 (O)													
Si	2.878	2.890	2.864	2.852	2.985	2.973	2.817	2.851	2.913	2.911	2.968	2.850	2.789	2.863
Aliv	1.120	1.103	1.136	1.146	1.014	1.022	1.179	1.140	1.088	1.085	1.028	1.148	1.203	1.131
Ti	0.000	0.001	0.000	0.001	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000
sum	3.998	3.994	4.000	3.999	3.999	3.996	3.996	3.991	4.001	3.996	3.996	3.999	3.992	3.994
Fe	0.000	0.002	0.002	0.003	0.000	0.006	0.000	0.001	0.002	0.002	0.004	0.003	0.008	0.000
Mn	0.000	0.001	0.000	0.000	0.000	0.003	0.002	0.000	0.000	0.000	0.000	0.001	0.000	0.001
Mg	0.000	0.000	0.000	0.001	0.000	0.001	0.000	0.000	0.001	0.001	0.001	0.000	0.000	0.001
Ca	0.121	0.111	0.116	0.125	0.001	0.001	0.171	0.132	0.053	0.099	0.002	0.122	0.169	0.109
Na	0.865	0.861	0.867	0.871	0.026	0.052	0.839	0.895	0.970	0.886	0.040	0.894	0.863	0.906
K	0.018	0.034	0.032	0.020	0.987	0.966	0.011	0.012	0.004	0.009	0.985	0.009	0.018	0.027
sum	1.004	1.009	1.017	1.020	1.014	1.029	1.023	1.040	1.030	0.997	1.032	1.029	1.058	1.044
	components													
An	12.1	11.0	11.4	12.3	0.1	0.1	16.7	12.7	5.2	10.0	0.2	11.9	16.1	10.5
Ab	86.2	85.6	85.4	85.7	2.6	5.1	82.2	86.1	94.4	89.1	3.9	87.2	82.2	86.9
Or	1.8	3.4	3.2	2.0	97.3	94.8	1.1	1.2	0.4	0.9	95.9	0.9	1.7	2.6

1 SF8-318
2 SF8-318
3 SI-2a
4 SI-2a
5 SI-2b
6 SI-2b
7 SI-2b
8 SI-2b, plag rim
9 SI-3
10 SI-3
11 SI-3
12 SI-3b, enclave
13 SI-3b, enclave
14 SI-3b, enclave

Table 6. (cont.) Feldspar Analyses, Sims Pluton, Nash and Wilson Counties, North Carolina

	Conner granitoid													
	15	16	17	18	19	20	21	22	23	24	25	26	27	28
SiO_2	65.0	66.4	62.1	63.2	66.4	68.1	61.2	62.3	63.3	67.6	65.7	62.4	66.5	63.5
TiO_2	0.00	0.01	0.05	0.03	0.01	0.01	0.01	0.03	0.03	0.00	0.00	0.03	0.00	0.03
Al_2O_3	20.9	19.7	18.5	22.5	19.6	19.8	23.3	22.8	23.1	19.3	21.1	18.4	19.6	18.3
FeO	0.11	0.13	0.00	0.00	0.17	0.10	0.08	0.24	0.00	0.04	0.02	0.11	0.03	0.06
MnO	0.02	0.00	0.04	0.00	0.01	0.02	0.00	0.02	0.00	0.00	0.02	0.02	0.03	0.00
MgO	0.00	0.02	0.01	0.02	0.03	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.00	0.00
CaO	1.73	0.51	0.02	3.62	0.55	0.61	4.97	4.07	4.19	0.13	1.80	0.02	0.17	0.06
Na_2O	10.7	11.1	0.92	9.55	10.8	11.3	8.64	9.16	9.65	11.7	10.5	0.65	11.1	0.57
K_2O	0.10	0.34	15.2	0.18	0.89	0.11	0.15	0.39	0.18	0.17	0.29	16.2	0.91	15.7
Total	98.56	98.21	96.84	99.10	98.46	100.05	98.35	99.01	100.45	98.94	99.44	97.85	98.34	98.22
	number of cations on the basis of 8 (O)													
Si	2.900	2.962	2.962	2.818	2.962	2.976	2.760	2.790	2.791	2.987	2.902	2.962	2.968	2.987
Aliv	1.098	1.037	1.043	1.180	1.032	1.020	1.236	1.202	1.199	1.007	1.098	1.031	1.030	1.014
Ti	0.000	0.000	0.002	0.001	0.000	0.000	0.000	0.001	0.001	0.000	0.000	0.001	0.000	0.001
sum	3.998	3.999	4.007	3.999	3.994	3.996	3.996	3.993	3.991	3.994	4.000	3.994	3.998	4.002
Fe	0.004	0.005	0.000	0.000	0.006	0.004	0.003	0.009	0.000	0.001	0.001	0.004	0.001	0.002
Mn	0.001	0.000	0.002	0.000	0.000	0.001	0.000	0.001	0.000	0.000	0.001	0.001	0.001	0.000
Mg	0.000	0.001	0.001	0.001	0.002	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.000	0.000
Ca	0.083	0.024	0.001	0.173	0.026	0.029	0.240	0.195	0.198	0.006	0.085	0.001	0.008	0.003
Na	0.925	0.960	0.085	0.825	0.933	0.961	0.755	0.796	0.825	1.006	0.903	0.060	0.962	0.052
K	0.006	0.019	0.925	0.010	0.051	0.006	0.009	0.022	0.010	0.010	0.016	0.980	0.052	0.944
sum	1.019	1.009	1.014	1.009	1.018	1.001	1.007	1.023	1.033	1.023	1.007	1.047	1.024	1.001
	components													
An	8.2	2.4	0.1	17.2	2.6	2.9	23.9	19.2	19.2	0.6	8.5	0.1	0.8	0.3
Ab	91.2	95.7	8.4	81.8	92.4	96.5	75.2	78.6	79.9	98.4	89.9	5.8	94.1	5.2
Or	0.6	1.9	91.5	1.0	5.0	0.6	0.9	2.2	1.0	1.0	1.6	94.1	5.1	94.5

15 SI-3b, enclave
16 SI-3b, enclave, exsolv. alk. fsp.
17 SI-3b, enclave, exsolv. alk. fsp.
18 SI-3b, enclave, plag w/ ms
19 SI-3b, enclave, plag. rim
20 SI-3b, enclave, w/ ms + cal
21 SI-3b, enclave, clot plag.
22 SI-4, grain core
23 SI-4, grain near rim
24 SI-4, grain rim
25 SI-4, exsolv. alk. fsp
26 SI-4, exsolv. alk. fsp
27 SI-4, exsolv. alk. fsp
28 SI-7, exsolv. alk. kfs

Table 6. (cont.) Feldspar Analyses, Sims Pluton, Nash and Wilson Counties, North Carolina

	Conner granitoid										*Sims granitoid*		
	29	30	31	32	33	34	35	36	37	38	39	40	41
SiO_2	63.7	64.4	67.2	63.6	64.0	67.3	64.3	63.9	65.1	63.3	63.2	67.4	64.0
TiO_2	0.00	0.01	0.01	0.00	0.03	0.01	0.03	0.01	0.00	0.00	0.03	0.00	0.03
Al_2O_3	22.9	22.2	19.8	18.6	18.1	20.1	23.3	18.3	22.5	23.1	18.1	19.5	21.6
FeO	0.00	0.07	0.06	0.00	0.00	0.08	0.00	0.15	0.00	0.08	0.05	0.03	0.04
MnO	0.06	0.00	0.05	0.02	0.01	0.00	0.00	0.06	0.02	0.00	0.00	0.02	0.00
MgO	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.00	0.00	0.00	0.01	0.00
CaO	3.96	3.30	0.14	0.00	0.08	0.86	3.90	0.02	3.27	4.36	0.01	0.33	3.16
Na_2O	9.41	9.95	11.8	0.45	0.55	11.6	9.66	0.44	9.77	9.39	0.27	11.2	10.1
K_2O	0.22	0.22	0.14	16.2	16.1	0.11	0.18	15.9	0.20	0.24	16.3	0.71	0.28
Total	100.25	100.15	99.20	98.87	98.87	100.06	101.38	98.80	100.86	100.47	97.96	99.20	99.21
	number of cations on the basis of 8 (O)												
Si	2.810	2.840	2.966	2.976	2.994	2.951	2.804	2.988	2.846	2.790	2.989	2.978	2.850
Aliv	1.188	1.153	1.030	1.028	1.000	1.038	1.196	1.011	1.157	1.201	1.008	1.016	1.135
Ti	0.000	0.000	0.000	0.000	0.001	0.000	0.001	0.000	0.000	0.000	0.001	0.000	0.001
sum	3.998	3.993	3.996	4.004	3.995	3.989	4.001	3.999	4.003	3.991	3.998	3.994	3.986
Fe	0.000	0.003	0.002	0.000	0.000	0.003	0.000	0.006	0.000	0.003	0.002	0.001	0.001
Mn	0.002	0.000	0.002	0.001	0.000	0.000	0.000	0.002	0.001	0.000	0.000	0.001	0.000
Mg	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.000	0.000	0.000	0.001	0.000
Ca	0.187	0.156	0.007	0.000	0.004	0.040	0.182	0.001	0.153	0.206	0.001	0.016	0.151
Na	0.804	0.851	1.013	0.041	0.050	0.988	0.817	0.040	0.828	0.803	0.025	0.963	0.870
K	0.012	0.012	0.008	0.967	0.960	0.006	0.010	0.950	0.011	0.013	0.984	0.040	0.016
sum	1.005	1.022	1.032	1.009	1.014	1.037	1.010	1.000	0.993	1.025	1.012	1.022	1.038
	components												
An	18.6	15.3	0.7	0.0	0.4	3.9	18.0	0.1	15.4	20.2	0.1	1.6	14.6
Ab	80.2	83.5	98.5	4.1	4.9	95.6	81.0	4.0	83.5	78.6	2.5	94.5	83.9
Or	1.2	1.2	0.8	95.9	94.7	0.6	1.0	95.9	1.1	1.3	97.4	3.9	1.5

29 SI-7, plag. near core
30 SI-7, plag. near rim
31 SI-7, exsolv. alk. kfs
32 SI-7, exsolv. alk. kfs
33 SI-11
34 SI-11, plag. rim
35 SI-11, plag. near core
36 SI-21a
37 SI-21a
38 SI-21a
39 SF7-163, exsolv. alk. fsp.
40 SF7-163, exsolv. alk. fsp.
41 SF7-163, plag. near core
42 SF7-163, plag. near rim

Table 6. (cont.) Feldspar Analyses, Sims Pluton, Nash and Wilson Counties, North Carolina

	Sims granitoid										*aplite*	
	42	43	44	45	46	47	48	49	50	51	52	53
SiO_2	64.4	66.5	67.5	62.8	65.1	69.1	66.9	63.3	66.7	68.4	64.9	67.7
TiO_2	0.00	0.00	0.00	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.00	0.01
Al_2O_3	21.4	20.6	19.9	18.0	18.5	20.5	20.1	18.4	19.2	19.7	18.2	20.5
FeO	0.13	0.00	0.10	0.02	0.00	0.02	0.00	0.00	0.04	0.00	0.01	0.08
MnO	0.04	0.00	0.00	0.03	0.00	0.00	0.03	0.00	0.00	0.00	0.03	0.00
MgO	0.01	0.01	0.01	0.02	0.00	0.01	0.03	0.00	0.00	0.01	0.00	0.00
CaO	2.66	1.36	0.32	0.02	0.09	0.75	0.59	0.01	0.32	0.12	0.02	1.39
Na_2O	10.0	11.0	12.0	0.49	0.49	11.4	11.7	0.42	11.5	11.9	0.44	11.1
K_2O	0.28	0.16	0.10	15.1	16.2	0.16	0.11	16.5	0.15	0.09	16.4	0.11
Total	98.92	99.63	99.93	96.50	100.40	101.96	99.48	98.65	97.92	100.23	100.00	100.89
	number of cations on the basis of 8 (O)											
Si	2.870	2.929	2.962	2.998	2.997	2.964	2.948	2.978	2.982	2.984	3.004	2.944
Aliv	1.124	1.069	1.028	1.010	1.002	1.038	1.045	1.018	1.009	1.014	0.991	1.049
Ti	0.000	0.000	0.000	0.001	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000
sum	3.994	3.998	3.990	4.009	4.000	4.003	3.994	3.997	3.991	3.998	3.995	3.993
Fe	0.005	0.000	0.004	0.001	0.000	0.001	0.000	0.000	0.001	0.000	0.000	0.003
Mn	0.002	0.000	0.000	0.001	0.000	0.000	0.001	0.000	0.000	0.000	0.001	0.000
Mg	0.001	0.001	0.001	0.001	0.000	0.001	0.002	0.000	0.000	0.001	0.000	0.000
Ca	0.127	0.064	0.015	0.001	0.004	0.034	0.028	0.001	0.015	0.006	0.001	0.065
Na	0.864	0.941	1.020	0.045	0.044	0.945	1.001	0.038	1.000	1.004	0.039	0.932
K	0.016	0.009	0.006	0.920	0.949	0.009	0.006	0.988	0.009	0.005	0.966	0.006
sum	1.015	1.015	1.046	0.969	0.997	0.990	1.038	1.027	1.025	1.016	1.007	1.006
	components											
An	12.6	6.3	1.4	0.1	0.4	3.4	2.7	0.1	1.5	0.6	0.1	6.5
Ab	85.8	92.8	98.0	4.7	4.4	95.6	96.7	3.7	97.7	98.9	3.9	92.9
Or	1.6	0.9	0.6	95.2	95.2	0.9	0.6	96.2	0.9	0.5	96.0	0.6

43 SF7-163, plag. rim
44 SI-14, w/ cal
45 SI-14, plag w/ ms + cal
46 SI-14
47 SI-26
48 SI-27
49 SI-27, exsolv. alk. kfs
50 SI-27, exsolv. alk. kfs.
51 SI-27a, enclave, plag w/ ms + cal
52 SI-27b,
53 SI-27b,

Table 7. Ilmenite Analyses, Sims Pluton, Nash and Wilson Counties, North Carolina

	Conner granitoid												*Sims granitoid*			*enclave*
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
TiO_2	45.2	51.1	50.8	54.6	49.3	49.6	48.8	49.5	48.3	48.1	46.0	48.1	46.3	45.9	49.6	50.9
Al_2O_3	0.03	0.00	0.03	0.31	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.02
Fe_2O_3	7.87	0.75	1.04	0.00	5.16	4.38	6.86	4.48	7.28	4.79	4.21	0.69	6.08	7.64	0.00	0.00
FeO	29.9	36.9	37.0	31.3	34.0	35.2	34.2	35.3	34.5	29.5	30.7	33.2	31.7	34.5	35.7	33.1
MnO	10.6	8.92	8.52	5.83	10.2	9.22	9.53	9.12	8.88	13.5	10.5	9.89	9.60	6.65	8.46	10.8
MgO	0.04	0.00	0.03	0.11	0.03	0.03	0.01	0.02	0.00	0.06	0.01	0.05	0.13	0.07	0.06	0.08
Total	93.64	97.67	97.42	92.15	98.70	98.43	99.40	98.43	98.96	95.95	91.42	91.97	93.81	94.76	93.82	94.90
	number of cations on the basis of 3 (O)															
Ti	0.919	0.993	0.989	1.081	0.950	0.957	0.934	0.956	0.930	0.952	0.956	0.992	0.938	0.923	1.002	1.011
Al	0.001	0.000	0.001	0.010	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.001
Fe^{3+}	0.160	0.015	0.020	0.000	0.100	0.085	0.132	0.087	0.140	0.095	0.088	0.014	0.123	0.154	0.000	0.000
sum	1.080	1.008	1.010	1.091	1.050	1.042	1.066	1.043	1.070	1.047	1.044	1.007	1.061	1.077	1.002	1.012
Fe^{2+}	0.675	0.798	0.802	0.688	0.728	0.757	0.728	0.758	0.738	0.649	0.711	0.762	0.714	0.771	0.802	0.732
Mn	0.243	0.195	0.187	0.130	0.221	0.200	0.206	0.198	0.192	0.302	0.245	0.230	0.219	0.151	0.193	0.241
Mg	0.002	0.000	0.001	0.004	0.001	0.001	0.000	0.001	0.000	0.002	0.000	0.002	0.005	0.003	0.002	0.003
sum	0.920	0.993	0.990	0.822	0.950	0.958	0.934	0.957	0.930	0.953	0.956	0.994	0.938	0.925	0.997	0.976

1 SF8-318	5 SI-3	9 SI-4	13 SF7-163
2 SI-2a	6 SI-3a	10 SI-11	14 SI-14
3 SI-2a	7 SI-3b	11 SI-11	15 SI-26
4 SI-2b	8 SI-3b	12 SI-21	16 SI-27a

Table 8. Hematite Analyses, Sims Pluton, Nash and Wilson Counties, North Carolina

	Conner granitoid		
	1	2	3
TiO_2	14.9	0.02	0.01
Al_2O_3	0.00	14.04	23.19
Fe_2O_3	69.8	0.01	0.02
FeO	11.1	72.2	54.1
MnO	2.29	10.4	16.7
MgO	0.02	2.14	4.05
Total	98.11	98.81	98.07
number of cations on the basis of 3 (O)			
Ti	0.298	0.280	0.461
Al	0.000	0.000	0.001
Fe^{3+}	1.402	1.439	1.077
Fe^{2+}	0.247	0.231	0.370
Mn	0.052	0.048	0.091
Mg	0.001	0.001	0.001
sum	2.000	1.999	2.001

1 SI-7
2 SI-7
3 SI-7

Table 9. Magnetite Analyses,
Sims Pluton,
Nash and Wilson Counties,
North Carolina

	Conner granitoid			
	1	2	3	4
SiO_2	0.05	0.02	0.02	0.04
TiO_2	0.17	0.00	0.00	0.08
Al_2O_3	0.06	0.05	0.04	0.00
Fe_2O_3	66.9	67.3	61.9	63.2
FeO	30.4	30.3	27.9	28.4
MnO	0.10	0.04	0.02	0.17
MgO	0.02	0.00	0.01	0.03
Total	97.70	97.71	89.89	91.92
	number of cations on the basis of 4 (O)			
Ti	0.005	0.000	0.000	0.003
Al	0.003	0.002	0.002	0.000
Fe^{3+}	1.985	1.997	1.997	1.993
Fe^{2+}	1.004	1.000	1.000	0.997
Mn	0.003	0.001	0.001	0.006
Mg	0.001	0.000	0.001	0.002
sum	3.001	3.000	3.001	3.001

1 SI-7 3 SI-14
2 SI-7 4 SI-14

Table 10. Rutile Analyses,
Sims Pluton,
Nash and Wilson Counties,
North Carolina

	Conner	*Sims*
	1	2
SiO_2	0.00	0.10
TiO_2	66.9	84.5
Al_2O_3	0.05	0.10
FeO	9.08	2.83
MnO	0.04	0.08
MgO	0.01	0.01
Nb_2O_5	(?)	
Total	76.08	87.62
	number of cations on the basis of 2 (O)	
Ti	0.929	0.980
Al	0.001	0.002
Fe	0.140	0.037
Mn	0.001	0.001
Mg	0.000	0.000
sum	1.071	1.020

1 SI-11
2 SI-26

Table 11. Chlorite Analyses, Sims Pluton,
Nash and Wilson Counties, North Carolina

	Conner granitoid				*Sims granitoid*				*aplite*
	1	2	3	4	5	6	7	8	9
SiO_2	26.2	24.6	24.9	27.7	27.1	28.0	29.0	28.5	27.7
TiO_2	0.25	0.06	0.07	0.09	0.04	0.07	0.00	0.06	0.06
Al_2O_3	20.2	20.8	21.6	18.9	18.7	18.9	20.5	20.3	19.7
FeO	31.3	32.3	32.1	26.2	22.4	22.7	22.9	23.3	25.3
MnO	0.96	0.99	1.54	1.09	0.92	0.70	0.88	0.91	0.96
MgO	9.24	9.36	8.84	13.7	16.3	15.7	13.4	15.8	13.5
CaO	0.04	0.01	0.05	0.03	0.04	0.08	0.28	0.04	0.02
Na_2O	0.07	0.00	0.00	0.01	0.01	0.03	0.07	0.00	0.00
K_2O	0.64	0.03	0.01	0.09	0.02	0.01	0.07	0.19	0.51
F	0.17	0.10	0.06	0.12	0.19	0.11	0.04	0.25	0.20
Cl	0.02	0.02	0.03	0.00	0.00	0.00	0.01	0.01	0.00
H_2O	11.0	10.9	11.0	11.3	11.1	11.3	11.5	11.6	11.3
Sum	100.09	99.17	100.20	99.23	96.82	97.60	98.65	100.96	99.25
O=F+Cl	0.08	0.05	0.03	0.05	0.08	0.05	0.02	0.11	0.08
Total	100.01	99.12	100.17	99.18	96.74	97.55	98.63	100.85	99.17
	number of cations on the basis of 18 (O, OH, F, Cl)								
Si	2.820	2.687	2.687	2.931	2.886	2.954	3.016	2.905	2.914
Al^{iv}	1.180	1.313	1.313	1.069	1.114	1.046	0.984	1.095	1.086
sum	4.000	4.000	4.000	4.000	4.000	4.000	4.000	4.000	4.000
Al^{vi}	1.385	1.364	1.437	1.285	1.233	1.303	1.530	1.339	1.360
Ti	0.020	0.005	0.006	0.008	0.004	0.006	0.000	0.005	0.005
Fe	2.814	2.956	2.904	2.312	1.993	2.002	1.994	1.988	2.222
Mn	0.088	0.092	0.141	0.098	0.083	0.062	0.078	0.079	0.086
Mg	1.482	1.527	1.425	2.150	2.584	2.461	2.073	2.403	2.116
Ca	0.000	0.001	0.006	0.003	0.004	0.009	0.031	0.004	0.002
Na	0.015	0.000	0.000	0.002	0.000	0.006	0.014	0.000	0.000
K	0.088	0.004	0.001	0.013	0.003	0.001	0.009	0.025	0.068
sum	5.892	5.949	5.920	5.871	5.904	5.850	5.729	5.843	5.859
Cl	0.004	0.004	0.005	0.000	0.001	0.000	0.002	0.002	0.000
F	0.058	0.035	0.021	0.040	0.066	0.037	0.013	0.081	0.067
OH	7.938	7.962	7.974	7.960	7.933	7.963	7.985	7.918	7.933
sum	8.000	8.001	8.000	8.000	8.000	8.000	8.000	8.001	8.000
F/(FM)	0.66	0.66	0.67	0.52	0.44	0.45	0.49	0.45	0.51

1 SI-2b, matrix chlorite
2 SI-3, matrix chlorite
3 SI-3a, matrix chlorite
4 SI-11, intergrown w/ biotite
5 SF7-163, matrix chlorite
6 SI-14, intergrown w/ biotite
7 SI-21a, matrix chlorite
8 SI-27, intergrown w/ biotite
9 SI-27b, matrix chlorite

Table 12. Epidote Analyses, Sims Pluton, North Carolina

	Conner granitoid					*Sims granitoid*			*aplite*
	1	2	3	4	5	6	7	8	9
SiO_2	36.9	41.1	40.7	37.9	36.7	37.0	38.0	38.6	37.8
TiO_2	0.04	0.06	0.07	0.07	0.02	0.06	0.03	0.24	0.16
Al_2O_3	21.4	31.0	21.2	22.0	21.8	22.0	22.6	21.6	22.4
Fe_2O_3	15.2	1.75	12.4	14.4	14.6	14.4	13.5	14.2	14.7
MnO	0.29	0.14	0.20	0.42	0.37	0.33	0.37	0.20	0.32
MgO	0.01	0.13	0.02	0.01	0.00	0.02	0.00	0.01	0.06
CaO	22.5	21.3	18.3	23.0	22.7	22.8	22.6	23.6	22.8
Na_2O	0.00	1.21	1.86	0.01	0.00	0.06	0.00	0.03	0.04
K_2O	0.03	0.04	0.12	0.00	0.00	0.00	0.00	0.02	0.19
F	0.01	0.00	0.04	0.00	0.01	0.01	0.05	0.01	0.04
Cl	0.00	0.03	0.02	0.01	0.00	0.02	0.01	0.02	0.02
H_2O	1.83	1.95	1.83	1.87	1.83	1.84	1.84	1.87	1.86
Sum	98.21	98.71	96.76	99.69	98.03	98.54	99.00	100.40	100.39
O=F+Cl	0.00	0.01	0.02	0.00	0.01	0.01	0.02	0.01	0.02
Total	98.21	98.70	96.74	99.69	98.02	98.53	98.98	100.39	100.37
	number of cations on the basis of 13 (O, OH, F, Cl)								
Si	3.012	3.147	3.292	3.036	2.995	3.004	3.049	3.065	3.007
Al^{iv}	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
sum	3.012	3.147	3.292	3.036	2.995	3.004	3.049	3.065	3.007
Al_{vi}	2.054	2.790	2.017	2.075	2.100	2.099	2.134	2.027	2.099
Ti	0.002	0.003	0.004	0.004	0.002	0.004	0.002	0.014	0.010
Fe	0.932	0.101	0.753	0.866	0.897	0.879	0.815	0.849	0.882
Mn	0.020	0.009	0.014	0.028	0.025	0.023	0.025	0.013	0.022
Mg	0.002	0.015	0.002	0.001	0.000	0.002	0.000	0.001	0.007
sum	3.008	2.903	2.788	2.973	3.024	3.007	2.976	2.904	3.020
Ca	1.967	1.743	1.577	1.976	1.983	1.984	1.941	2.006	1.946
Na	0.000	0.179	0.292	0.002	0.000	0.009	0.000	0.005	0.006
K	0.003	0.004	0.012	0.000	0.001	0.000	0.001	0.002	0.019
sum	1.970	1.926	1.881	1.978	1.984	1.993	1.942	2.013	1.971
Cl	0.000	0.004	0.003	0.001	0.003	0.003	0.001	0.003	0.003
F	0.003	0.000	0.010	0.000	0.000	0.003	0.013	0.003	0.010
OH	0.997	0.996	0.987	0.999	0.997	0.995	0.986	0.995	0.987
sum	1.000	1.000	1.000	1.000	1.000	1.001	1.000	1.001	1.000
	components								
Ps	31.0	3.5	27.0	29.2	29.7	29.3	27.4	29.4	29.4
Cz	68.3	96.2	72.4	69.9	69.5	69.9	71.8	70.2	69.9
Pd	0.7	0.3	0.5	0.9	0.8	0.8	0.8	0.4	0.7

1 SF8-318, epidote w/ ms. + bt.
2 SI-3, epidote in plagioclase
3 SI-4, epidote in plagioclase
4 SI-11, epidote w/ ms. + chl.
5 SI-21a, epidote w/ ms. + bt.
6 SF7-163, epdiote w/ chl.
7 SI-14, epidote w/ ms. + bt
8 SI-27, epdiote w/ ms. + bt.
9 SI-27b, matrix epidote

Table 13. Carbonate Analyses, Sims Pluton, Nash and Wilson Counties, North Carolina

	Conner		*Sims*		
	1	2	3	4	5
FeO	0.45	1.49	0.72	0.88	0.00
MnO	1.26	4.35	2.23	3.15	0.78
MgO	0.07	0.29	0.21	0.38	0.05
CaO	55.9	51.6	52.8	55.7	57.7
CO_2	45.0	44.4	43.5	46.6	45.8
Total	102.68	102.13	99.46	106.71	104.33
number of cations on the basis of 3 (O)					
Fe	0.006	0.021	0.010	0.012	0.000
Mn	0.017	0.061	0.032	0.042	0.011
Mg	0.002	0.007	0.005	0.009	0.001
Ca	0.975	0.912	0.953	0.938	0.988
sum	1.000	1.001	1.000	1.001	1.000
C	1.000	1.000	1.000	1.000	1.000

1 SI-3a, calcite in plagioclase
2 SI-3b, calcite in plagioclase
3 SI-14, calcite in plagioclase
4 SI-27, calcite w/ muscovite + plagioclase
5 SI-27a, calcite in plagioclase

Table 14. Titanite Analyses,
Sims Pluton,
Nash and Wilson Counties,
North Carolina

	Conner	
	1	2
SiO_2	31.5	22.0
TiO_2	26.7	40.8
Al_2O_3	7.18	2.65
FeO	2.11	10.28
MnO	0.17	4.21
MgO	0.12	0.00
CaO	29.4	19.6
Na_2O	0.00	0.01
K_2O	0.02	0.01
F	1.72	0.64
Cl	0.00	0.01
Sum	98.92	
O=F+C	0.72	
Total	98.20	100.21
number of cations on the basis of 5 (O, OH, F, Cl)		
Si	1.030	
Ti	0.658	
Al	0.277	
Fe	0.052	
sum	0.987	
Mn	0.005	
Mg	0.006	
Ca	1.030	
Na	0.000	
K	0.001	
sum	1.042	
Cl	0.000	
F	0.176	
sum	1.985	

1. SI-26, alter. of ilm, w/ ru
2. SI-27a, mixture w/ ilm

Table 15. Soil-gas Radon Concentrations, Sims pluton area, North Carolina

rock type	Sample	radon pC/l	std. dev.	duplicate average
Conner granitoid				
	RnSI3	4428	19	
	RnSI4	2622	21	
	RnSI5	2289	19	
	RnSI6	2232	22	
	RnSI8	1242	13	
	RnSI11	3399	16	
	RnSI12	682	8	
	RnSI13	2756	24	
	RnSI14	1371	4	
	RnSI15	2261	8	
	RnSI17	3248	24	
	RnSI22	1799	10	
	RnSI23	5215	9	
	RnSI24	6341	36	
	RnSI25	2057	15	
	RnSI26	3238	32	
	RnSI27	2413	16	
	RnSI28	2675	20	
	RnSI28(dup)	2730	3	2701
	RnSI33	2119	25	
	RnSI34	2177	15	
	RnSI35	1093	7	
	average	2652		
	std. dev.	1354		
Sims granitoid				
	RnSI18	3191	24	
	RnSI19	1151	10	
	RnSI19(dup)	1112	4	1131
greisen				
	RnSI10	1514	20	
	RnSI10(dup)	1456	10	1485
Quaternary alluvium				
	RnSI29	1363	14	

rock type	Sample	radon pC/l	std. dev.	duplicate average
Eastern slate belt rocks				
	RnSI1	1180	19	
	RnSI2	1483	11	
	RnSI7	1318	19	
	RnSI9	1067	6	
	RnSI20	1810	11	
	RnSI30	738	14	
	RnSI31	920	11	
	RnSI32	1019	11	
	average	1192		
	std. dev.	340		
Atlantic Coastal plain rocks				
Bailey Springs Heavy Mineral Deposit				
	RnSI16	614	6	
	RnSI21	1175	12	
	RnSI36	530	9	
	RnSI37	696	7	
	RnSI38	797	9	
	RnSI38(dup)	733	7	765
	RnBS1	1178	8	
	RnBS2	1052	7	
	RnBS3	606	4	
	RnBS4	300	8	
	RnBS5	361	8	
	RnBS6	215	10	
	RnBS6(dup)	160	5	188
	RnBS7	708	9	
	RnBS8	1048	8	
	RnBS9	599	7	
	RnBS10	229	8	
	RnBS11	223	3	
	RnBS12	386	9	
	RnBS13	632	6	
	RnBS14	408	8	
	RnBS15	306	4	
	RnBS16	105	1	

rock type	Sample	radon pC/l	std. dev.	duplicate average
	RnBS16(dup)	111	4	108
	RnBS17	522	7	
	RnBS18	57	2	
	RnBS19	120	5	
	RnBS20	469	6	
	RnBS21	136	1	
	RnBS22	158	2	
	RnBS23	203	2	
	RnBS24	187	1	
	RnBS25	210	4	
	RnBS26	424	5	
	RnBS27	317	4	
	RnBS27(dup)	330	6	324
	RnBS28	535	4	
	RnBS29	341	4	
	RnBS30	1391	10	
	RnBS31	321	4	
	RnBS32	322	4	
	RnBS33	656	8	
	RnBS34	1482	8	
	RnBS35	1091	11	
	RnBS36	61	2	
	RnBS37	239	2	
	RnBS37(dup)	256	5	248
	RnBS38	250	6	
	RnBS39	667	8	
	RnBS40	2	2	
	RnBS41	30	2	
	RnBS42	232	4	
	RnBS43	452	11	
	RnBS44	163	3	
	RnBS45	936	5	
	RnBS46	230	5	
	RnBS47	238	4	
	RnBS47(dup)	110	1	174
	RnBS48	243	7	
	median	323		
	average	455		

Table 16. Groundwater Radon Concentrations, Sims pluton area, Nash and Wilson Counties, North Carolina

Location	well depth (feet)	radon (pC/l)	std. dev.	duplicate average
Conner granitoid				
RnwSI02	145	29463	39	
RnwSI02(dup)	145	27161	36	28312
RnwSI03	170	10006	20	
RnwSI04	250	4897	17	
RnwSI05	140	12669	27	
RnwSI06	270	8238	14	
RnwSI09	190	23998	49	
RnwSI11	?	30646	73	
RnwSI13	424	28864	46	
RnwSI16	75-100	20682	12	
RnwSI17	>100	21279	39	
RnwSI18	435	15568	44	
RnwSI44	355	15518	31	
RnwSI45	105	26701	53	
RnwSI46	267	28774	63	
RnwSI14	290	60402	115	
RnwSI15	178	24601	63	
Sims granitoid				
RnwSI19	>100	19503	31	
RnwSI20	>100	6903	14	
RnwSI21	330	42270	94	
RnwSI22	106	17009	44	
RnwSI22(dup)	106	16590	31	16800
RnwSI24	231	65895	125	
RnwSI25	314	37573	48	
RnwSI38	312	33154	52	
RnwSI39	234	19820	63	
RnwSI40	84	18368	53	
RnwSI41	87	17640	72	
RnwSI42	240	14385	30	
RnwSI42(dup)	240	13113	13	13749
RnwSI43	187	31871	74	
	median	20251		
	average	24175		

Location	well depth (feet)	radon (pC/l)	std. dev.	duplicate average
greisen				
RnwSI07	130	25652	71	
RnwSI10	120	2970	12	
Carolina slate belt wall rocks				
RnwSI01	85	2425	13	
RnwSI08	170	941	5	
RnwSI12	192	3545	16	
RnwSI12(dup)	192	3929	17	
RnwSI23	166	4140	18	
RnwSI26	230	-316	9	
RnwSI27	220	1840	15	
RnwSI28	112	2506	17	
RnwSI29	200	1155	4	
RnwSI30	117	2137	10	
RnwSI31	112	2353	11	
RnwSI32	120	2487	9	
RnwSI32(dup)	120	2366	14	
RnwSI33	130	2041	8	
RnwSI34	270	1402	7	
RnwSI35	>200	1320	4	
RnwSI36	126	1959	14	
RnwSI37	160	1161	3	
	median	2041		
	average	2103		
Atlantic coastal plain rocks				
RnwBS-01	35	632	9	
RnwBS-02	40	1371	11	
RnwBS-03	20	6780	10	
RnwBS-04	32	954	11	
	median	1163		
	average	2434		

Table 17. Aggregate Tests, Sims granite, Neverson Quarry
Wilson County, North Carolina (N. C. Dept. of Transportation)

Sample Date	L. A. Wear (% Loss) Grades A	B	C	Del.Sub.	Specific Gravity Grades A	B	C	Sodium Sulphate Soundness % loss at 5 cycles 1.5-0.75	0.75-0.3/8	3/8-#4
12/13/82	33	32	31		2.63	2.63	2.63	0.5	0.5	1.3
12/22/83	31	30	28	0.0	2.62	2.64	2.61			
12/14/84	31	31	29	0.0	2.65	2.65	2.63			
11/20/85	29	29	28	0.0	2.64	2.65	2.60	0.0	0.2	1.0
12/11/86	33	32	30	0.0	2.63	2.63	2.63			
12/8/87	30	31	33	0.0	2.63	2.63	2.62			
12/6/88	32	30	30	0.0	2.64	2.64	2.62	0.3	0.3	0.7
12/15/89	31	30	31	0.0	2.65	2.66	2.64			
11/29/90	33	33	35	0.0	2.64	2.63	2.63			
11/18/91	30	30	29	0.0	2.63	2.63	2.61	0.0	0.3	0.7
12/16/92	29	30	34	0.0	2.63	2.63	2.61			
12/10/93	32	32	37		2.61	2.63	2.62			

Date Due

OCT 1 6 1998	ILL	5144038	